Report on natural resources for food and agriculture in Latin America and the Caribbean

FAO
ENVIRONMENT
AND ENERGY
PAPER

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Rome, 1986

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M-08
ISBN 92-5-102512-6

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FOREWORD

The Latin America and Caribbean Region covers an immense latitudinal and altitudinal range, with a correspondingly rich biota and physiography. The region has the most extensive humid tropical forests in the world, alpine landscapes with snow-capped peaks at the equator, coastal deserts, and plains such as the tropical llanos and temperate pampas. Most of the population is found in the tropics and sub-tropics. In 1985, the estimated population of the region was 405 million. Average regional growth rates are 2.7% for Central America, 2.1% for South America, and 1.5% for the Caribbean. At current rates, the population will probably exceed 560 million by the year 2000.

Migration to urban areas is a serious problem in the region because of the numbers of people involved, and the political and economic implications. It is estimated that 75% of the population of the region will be living in cities by the end of the century. This growing urban population will make increasing demands on natural resources for agricultural, forestry and fishery products.

The most suitable areas for agriculture are, to a large extent, already occupied by cattle ranches, sugarcane, cacao, bananas and cotton plantations, designed to produce foreign exchange. Most of the rural people live on the more marginal lands where productive agriculture is difficult to sustain, and there is persistent poverty and intensive use of natural resources. Although colonization of new lands may eventually contribute to agricultural production, the significant increases will likely come from intensifying production on existing fertile lands.

This report examines the role of natural resources in agricultural and rural development in Latin America and the Caribbean, and reviews some of the problems in managing these resources to meet increasing needs. It is an initial attempt to relate natural resources potential and ecological conditions to food and agricultural production in the region. It is intended to update the report periodically, monitor trends and identify emerging issues which can be addressed within FAO's mandate for sustainable use of natural resources.

One of a series covering the various regions, the report was initiated by the Environment and Energy Programmes Coordinating Centre, (Research and Technology Development Division), in cooperation with the Interdepartmental Working Group on Environment and Energy. Dr. Joshua Dickinson prepared the report; Ms Maryam Niamir incorporated technical revisions and prepared the chapter on range and livestock production.

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1. CLIMATE, SOIL AND LAND USE

1.1 ECOLOGICAL LIFE ZONES

The Holdridge Life Zone System provides an ecological context for discussion of climate, soils and land capability (Holdridge, 1967). This departure from conventional European and North American approaches which focus on soil characteristics is necessitated by the complexity of the environment which supports agriculture and forestry in the humid tropics. The more densely populated areas of Central and Andean South America may have as many as twenty distinct agro-ecological zones within a 50-km radius. The System is widely used in Latin America for rural development planning and Life Zone maps have been published for most of the countries of Central and Tropical South America, as well as for several Caribbean islands. (Espinal, 1963; Holdridge, 1962; Onern, 1976; Tosi, 1971) (Fig. 1).

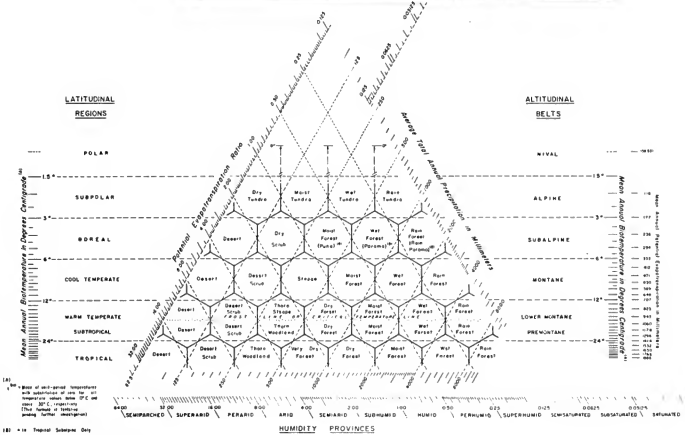
Ecosystems are described on a world-wide scale based on three climatic parameters: mean annual temperature, precipitation, and potential evapotranspiration (PET). The Life Zones defined by these parameters are prefixed by latitudinal and altitudinal indicators to identify them. For example, the tropical premontane dry forest has a mean annual temperature range from 16 to 24°C, precipitation between 500 and 1 000 mm, and a ratio between evapotranspiration and precipitation ranging from 1.0 to 2.0.

Within a Life Zone, associations are found reflecting atypical or azonal edaphic, hydric or atmospheric conditions. Geologic and geomorphic processes, for example, have resulted in extensive areas of sterile, excessively-drained soils in the granite and sandstone Guiana Shield of Venezuela and Brazil. Recent alluvium or the fertile *terra roxa* soils derived *in situ* on basalt are examples of azonal fertile edaphic associations. The extensive treeless areas of the Venezuelan llanos reflect a hydric association of the Tropical Dry Forest Life Zone due to frequent flooding and a high water table. Probably the most common atmospheric association in Latin America is the cloud or mist associations where moisture is higher than measured in rain gauges. Associations may exist in combination and are reflected in distinctive vegetation characteristics and land-use options. Topography and slope reflect geologic, climatic and geomorphic processes and are associated with edaphic associations.

A major division is made between Dry and Humid Life Zones. The "Unity Line" occurs where annual potential evapotranspiration (PET) is equal to precipitation: PET/P = 1. In all Humid Life Zones, precipitation is greater than potential evapotranspiration. Dry Life Zones are distinguished by precipitation being less than potential evapotranspiration. See ratios of potential evapotranspiration to precipitation in Fig. 1.

Cold, a limiting factor affecting huge areas across the northern hemisphere, affects only small areas of the tropical Andes (above 4 000 metres) and extreme southern Chile and Argentina.

Fig. 1. Diagram for the classification of World Life Zones or plant formations



Source: Holdridge, 1967.

The most reliable indicator in predicting the productivity of agriculture and concentration of population in Latin America and the Caribbean since pre-Colombian times is the PET/P = 1 Unity Line. When Latin American capital cities are plotted on a Life Zone diagram, 19 fall in the Life Zones flanking the Unity Line. The exceptions are Lima (Peru) and Santiago (Chile). Lima is a major seaport surrounded by irrigated land (the original Spanish and Inca capitals were on the Unity Line in the Andes). Santiago lies to the dry side of the Line in a valley with good water resources. For many years, the Spaniards were constrained from settlement nearer the Unity Line to the south by the belligerence of the Araucarian Indians.

According to the Economic Commission for Latin America (ECLA), 90% of the Latin American population live in areas with rainfall of from 500 to 2 000 millimeters. When corrected for elevation, this corresponds over wide areas to the better soils and topography of the five Life Zones flanking the Unity Line, with preference given to the drier side of the Line in lower, warmer areas. The other 10% of the population is divided between arid (or irrigated) and excessively wet areas (ECLA, 1979).

Zonal or azonal fertile soils, where precipitation and potential evapotranspiration are approximately equal, have neither excessive leaching nor accumulation of salts. During the dry fallow season, a net upward movement of nutrients occurs through evaporation and capillary movement. Weeds and pest populations tend to die back. This is analogous to the temperate winter fallow period.

1.2 DRY CLIMATES

Areas where moisture is insufficient to support most types of agriculture (PET twice precipitation), cover a relatively small area in Latin America and the Caribbean, principally along the Pacific coast of South America and in northern Mexico (Table 1.1). Irrigation is used successfully to produce crops in areas where exotic streams cross dry lands, although only 7% of the cultivated land in the region is under irrigation (FAO, 1984a).

The problem of dry climates is more severe in areas where evapotranspiration exceeds rainfall by a factor of 1.5 to 2.5, because land-use practices from more humid Life Zones are extended into these areas by the poorest farmers. Precipitation is not only marginal for crops, but tends to be less reliable and more "aggressive", often occurring as violent thunderstorms with resultant high runoff and erosion. When dry areas habitually subjected to overgrazing and fuelwood cutting are exposed to sporadic violent storms, they become rapidly degraded. Because of low biological productivity, recovery is slow even with careful management practices.

Advances in agriculture in dry areas have been achieved mainly by overcoming the physical stress of lack of sufficient water to grow crops. Some of the most productive irrigated agriculture is found in the driest areas of the hemisphere. Topography restricts irrigation to areas of level valley and coastal alluvium where abundant surface water from More Humid Life Zones can be tapped. Irrigated agriculture in the dry tropics allows the use of intensive agronomic and hydraulic engineering practices from the mid-latitudes with a minimum of adaptation.

Irrigated agriculture can be highly productive and profitable. In Mexico for example, 80% of the increase in agricultural production during the 1960s took place on less than 4% of the production units, mostly in the irrigated north (Dourojeanni, 1982, p. 69). The cost of irrigation is high and the technical competence of the users must also be high. Small farmers, lacking both capital and technical expertise, often fail. Poor water management can result in salinization of soils.

Table 1.1 Arid and semi-arid lands in the region

Region/country	Arid area	% of region/country	Semi-arid area	% of region/country
	(sq km)		(sq km)	
NORTH AMERICA				
Mexico	493 136	25	295 882	15
Total	493 136	25	295 882	15
ANDEAN				
Bolivia	164 786	15	109 857	10
Ecuador	-	-	14 178	5
Peru	257 042	20	-	-
Venezuela	-	-	45 602	5
Total	421 828	9	169 637	4
ATLANTIC				
Brazil	85 118	1	507 920	6
Parguay	-	-	20 337	5
Total	85 118	1	528 257	6
SOUTHERN TIER (a)				
Argentina	833 066	30	833 066	30
Chile	302 779	40	37 848	5
Total	1 135 845	32	870 914	24
SOUTH AMERICA	1 642 791	9	1 568 808	9
LATIN AMERICA/ CARIBBEAN	2 135 927	11	1 864 690	9

(a) Excluding Antarctic territories.

Source: Paylore & Greenwell, 1979.

Although pest problems are less severe in the dry tropics than in the wet, lack of effective pest management practices can lead to heavy use of pesticides with adverse effects on humans, downstream ecosystems and the economic viability of the operation itself (Barducci, 1972, pp. 423-438).

Dry lands have a productive potential far greater than what is being exploited in the region today. The rediscovery of water conservation practices common in pre-Colombian America and the Middle East, as well as the application of technologies such as drip irrigation and genetic engineering to achieve drought resistence, offer possibilities for increasing agricultural production.

1.3 VERY HUMID TROPICS

Very Humid Life Zones (evapotranspiration less than half precipitation) have had low population densities since pre-historic times. They encompass extensive lands in the Amazon basin including the steeply sloping "Ceja de Montana" along the eastern front of the Andes where rainfall ranges from 3 000 to 6 000 millimeters per year. Other very humid zones include a small area in the Gulf of Campeche in Mexico and a narrow band running from Belize along the Caribbean coast to eastern Panama crossing to the Pacific side and extending down to northern Ecuador. The highest population densities in these humid areas are along major floodplain rivers where atypically fertile alluvial soils are found, fish are abundant and there is access to markets for forest products.

During the last three decades roads have penetrated these areas and extensive spontaneous settlement has occurred (Nelson, 1973). However, poor soils and lack of appropriate technologies have limited socio-economic development. In the very humid tropics markedly different conditions prevail than are found in the drier, higher tropics, drastically affecting the viability of the Iberian and mid-latitude crops and cropping systems.

The difference in nutrient dynamics between the humid mid-latitudes and the wet tropics is poorly understood. A mid-latitude forest ecosystem has 25% of its nutrients tied up in living biomass, the remaining 75% being available in the soil. The reverse is true in the wet tropics where most of the nutrients are in the living vegetation. An efficient root system rapidly recycles nutrients in dead organic matter back into the above-ground living component. With no winter, nutrient cycling is rapid and almost continuous. When a mid-latitude forest is cleared 75% of the nutrients remain in the soil for crop production once a year. In contrast, when tropical forests are cleared and burned, a flush of nutrients representing most of the stock, is available in the ash and then rapidly washed or leached away.

In addition to erosion and mass movement when soils are cleared and exposed to heavy rainfall, extensive areas with low cation exchange capacities are subject to chemical erosion due to leaching. Fertilizers are rapidly leached from the root zone, removed in runoff or rendered chemically unavailable to crops (FAO/UNEP/Unesco, 1979, pp. 16-17). Soils with incomplete plant cover are subject to rapid oxidation of organic matter with resultant physical degradation, loss of nutrients and erosion (FAO/UNEP/Unesco, 1979, p.19). Cattle grazing also results in the degradation of soils due to compaction and increased organic matter oxidation resulting from annual burning and exposure to direct solar radiation.

The primary challenge in the very humid tropics is to overcome biological competition between crop plants on the one hand, and weeds, pests and diseases, on the other. Primitive agriculturists have taditionally used two strategies to produce food. One is shifting cultivation, using fire to release nutrients and destroy weeds and pests, which permits several harvests before production declines. The other is the intensively managed dooryard garden which imitates the structure and diversity of successional forests (Ewel et al, 1982).

Conventional crop and pasture monocultures are difficult to sustain at high levels of productivity in the Very Humid Life Zones. Capital and energy-intensive palm oil and banana plantations have penetrated the more humid tropics. However, these systems are costly and complex to serve as models for basic food production.

Knowledge is lacking about alternative values and uses of the very humid tropical environment. The forest products industry uses only a small fraction of the tree species. Screening of organisms for medicinal and other uses is promising but slow. Indigenous cultures that have evolved sound management practices are largely ignored and research to develop farming systems has only begun (Wilson, 1984). Because the very humid tropics are not attractive for settlement, infrastructure in the form of roads and facilities for health care, education, research, extension and marketing services is lacking.

1.4 SOILS OF THE REGION

The physical and chemical characteristics of the soils of Latin America and the Caribbean described and mapped in Volumes III and IV of the Soil Map of the World (FAO/Unesco, 1971-75) provide a widely accepted information base at a scale of 1:5 000 000. The South American volume observes that an outstanding feature of South American soils is their low natural fertility. Approximately 50% of the continent consists of various kinds of Ferralsols, Orthic Arenosols and Ferralic Arenosols, all low in cation exchange capacity and in exchangeable bases.

Another limitation which severely affects the agricultural use of the soils is deficiency of water. Broadly speaking, 20% of South America has semi-arid or arid climates, making agriculture without irrigation hazardous or impossible. The soils are mainly Yermasols, Zerosols, Regosols, Lithosols, salt-affected soils like Solonchaks and Solonetz, Ferric Luvisols and Chromic Luvisols.

There are also extensive areas with poor drainage, which make up about 10% of the continent. Here soils are mostly Gleysols, Plinthic Acrisols, Vertisols and Planosols.

The large area of steeplands in the Andes makes up 10% of the continent. Apart from Lithosols, which are dominant, Dystric Cambisols, Andosols and Arthic Acrisols are important, their occurrence being clearly related to altitude and parent material. These are acid soils, but relatively large areas of eutrophic soils can also be found in the inter-Andean valleys and on some foothills. These include Kastanozems, Phaeozems, Chromic Luvisols and Eutric Cambisols.

Regions which consist mainly of soils not having these limitations are rare in South America and extend over less than 10% of the total area. Important soils in these regions are Phaeozems, Kastanozems, Ferric Luvisols, the Rhodic Ferralsols with medium to high base status, Eutric Nitosols and Chromic Luvisols.

However, although the area of productive soil is limited, much of it is still uncultivated or cultivated by traditional methods. Substantial increases in agricultural production are therefore possible.

In most of the countries of the region, governments have soil maps at scales appropriate to their needs. In Peru, for example, the National Resources Office (ONERN), has large-scale soil maps for all major irrigation projects. Smaller scale maps (1:50 000 to 1:100 000) are available for rainfed agricultural projects in the Andes and in the eastern lowlands.

The Guanare-Masparro Project in Venezuela found that a geomorphological study had certain advantages over a soil survey. The original study employed traditional soil survey techniques with extensive field work and air photograph interpretation to produce a soil association map at an original scale of 1:100 000. The geomorphologist using the same air photographs was able to deduce the basic soil characteristics from a map of depositional landforms interpreted from vegetative patterns. This combined geomorphic, vegetation, and soils map was obtained at a fraction of the cost of traditional soils mapping. The advantage of the geomorphic map is that it reveals actual patterns, shapes, and orientations of landforms and associated soils, details which are lost in a map grouping soil associations. This map has been an invaluable aid in the assessment of least-cost routings for drains and roads, location of population centres, and land-use planning (Dickinson, 1982).

1.5 LAND RESOURCE AVAILABILITY

No issue in development is subject to wider variations in interpretation than land resources availability. "Land" in this broad context refers to (a) arable land with soil, slope and moisture conditions suitable for crop and animal production; (b) forest land capable of sustained production of fuelwood and forest products; and (c) protective land providing multiple services of water, erosion control, waste treatment and recreation.

Cultivated land forms 65.5% of the potential in Mexico; 74.1% in Central America; 63.9% in South America and 91.2% in the Caribbean islands (Annex Table 5). The discrepancy between land potentially available and land actually used has two dimensions - accessibility and suitability. A third dimension is the feasibility of increasing production through more intensive use of either presently occupied lands or new lands.

1.5.1 Land accessibility

There is a considerble differance between the availability of arable land and its accessibility for productive use by small and medium-scale farmers. FAO indicates that this problem is more acute in Latin America than elsewhere in the developing world (FAO, 1984a). In the region as a whole, 8% of land holdings cover 80% of the area. Much of the land used for subsistence and basic food crop production is not suitable for agriculture because of its shallow, rocky soil and potential for erosion. In many countries, a high percentage of basic food crops comes from steep lands (Table 1.2). The best agricultural land is generally under-utilized, being in large holdings for extensive cattle production.

Table 1.2 Contribution of steep slopes to agricultural output in Tropical America in the mid-1970s

Country	Steep land as % of arable land	Contribution to total agricultural production including coffee	 excluding coffee
Andes	%	%	%
Ecuador	25	42	33
Colombia	25	38	26
Peru	25	22	19
Central America			
Guatemala	30	45	26
El Salvador	40	75	18
Honduras	15	38	19
Caribbean			
Haiti	70	50	30
Dominican Rep.	15	43	31

Source: Adapted from Posner & McPherson, 1982.

Smallholdings comprise four fifths of the farm units in Latin America, although most of the land is in large farms. Despite their lack of access to productive resources (land, credit, technical and marketing assistance) small farms produce two fifths of the domestically consumed products and one third of the export products (Lopez, 1982). In Honduras for example, farms of less than 5 hectares comprise 65% of the total farms, though occupying only 9% of the land.

At the other end of the spectrum, farms larger than 50 hectares comprise 4% of all farms and occupy 56% of the land. (JRB, 1982). Improvement in small farm productivity in Latin America cannot directly alleviate the serious socio-economic problem of the 70% of the rural population living at subsistence level: half with inadequate land resources and half with no land at all (FAO, 1979).

The land-use planner is faced with a series of dilemmas. Low natural fertility is exacerbated by the susceptibility of humid tropical soils to chemical erosion (leaching) when cleared and used for annual crops and pasture. The costs of establishing and maintaining agriculture on these fragile lands is higher than on better soils, while the potential yields are lower.

On steep lands in Jamaica it was found that crop yields were substantially higher during the first two years under shifting cultivation than on land where conservation measures had been applied (Table 1.3). Under such conditions poor farmers find terracing and other conservation measures economically unattractive. If small farmers are to have access to better land with the potential for increasing agricultural production with less soil degradation, the political difficulties associated with major land reform must be faced.

Table 1.3 Production of yellow yams from runoff plots in Jamaica (tonnes/hectares/year)

	Year				
Treatment	1	2	3	4	Average
Traditional method					
Total production	56.3	53.1	33.1	26.4	40.0
Saleable production	31.6	37.8	22.0	16.8	26.9
Bench terraces					
Total production	35.3	44.2	32.6	37.8	38.5
Saleable production	18.5	30.4	21.0	23.2	23.2
Hillside ditches and contour mounds					
Total production	37.5	44.5	39.8	37.3	40.0
Saleable production	20.5	29.6	26.2	23.2	24.9
Hillside ditches and hills					
Total production	43.2	47.2	37.1	35.3	40.1
Saleable production	24.9	33.3	25.2	23.5	26.7

Source: Sheng & Michaelson, 1973.

1.5.2 Land Suitability

Tabulated data allow useful comparisons to be made if the analyst has an intimate knowledge of the ecological differences among regions, socio-economic factors, and the assumptions made in defining land use potential. Arable land in one country or among countries may vary widely in productive potential, controlling factors not being apparent in aggregate statistics (Annex Table 5). What can best be produced as determined by moisture and temperature regime can be inferred from the Life Zone. Generally, zonal soils of the lowland humid tropics are less fertile than soils at higher elevations and latitudes.

Grasslands in the llanos of Venezuela or Colombia with a carrying capacity of one cow per 3 hectares differ from Uruguay or Argentina where temperate Pampas may support 3 cows per hectare. Large areas of unimproved pastures in humid and wet forest areas of Honduras, Peru or Brazil may be as productive as the pampas during the first year after establishment and fall to a level closer to that of the llanos when nutrient leaching and weed invasion become pronounced.

Much discussed is the productive potential of extensive areas of Tropical Moist and Wet Forest Life Zones. These areas have remained sparsely populated through pre-Columbian and colonial up to modern times. This indicates that caution should be used in determining whether improving and intensifying agriculture where people are concentrated should be emphasized or whether colonization of tropical forests would be more beneficial.

One view is that production in the more humid lowland tropics can be improved substantially by the application of capital-intensive soil management technology to annual crop production (FAO 1981a; Higgins *et al* 1982; Sanchez, 1982). Those versed in Life Zone ecology urge *sustained* management of forests for wood products and tree crop production in the more humid tropics with intensification of food crop production in those Life Zones where population is concentrated (Tropical Science Centre, 1982; Tosi, 1975; NRC, 1982).

Much of the best land, technical expertise, chemicals, machinery and credit, especially in the lowland humid tropics, are devoted to the production of non-nutritive, luxury crops and feed crops for export. There is essentially no market for many indigenous products. Few people are left who know the diverse range of plants and animals or how to manage them. In the Andes, puinoa (*Chenopodium* sp.) has been largely abandoned in favour of bread and pasta *made from imported* wheat. More nutritive and easier to cultivate pot herbs (yuyos) have been supplanted by European greens (Hurtado, 1977).

Land suitable for agriculture is used for extensive livestock production (with cattle dominant), often for export. More than half a million hectares of abandoned agricultural terraces are extensively grazed in Peru.

1.5.3 Intensification of land use

The wide disparities in estimates of arable land are probably due to the fact that natural fertility and manageability are not taken into account when calculating the arable land base of a country. Table 1.4 shows how flexible the definition can be. In all the countries covered, agriculture has potential for expansion; in Peru by a factor of more than ten. With high levels of input, major increases in production can be achieved, mainly on land under intensive use, obviating the need for expansion of the arable land base.

Table 1.4 Arable land base and potential in some countries of the region

Country	Area of arable land in use (1)	% of national territory	Total potential (2)	
			Area	% of national territory
	(sq km)		(sq km)	
Bolivia	32 500	3	300 000	27
Colombia	40 500	4	439 730	39
Haiti	5 480	20	6 450	23
Honduras	15 650	14	32 670	29
Ecuador	17 550	6	125 320	46
El Salvador	5 600	27	13 200	62
Peru	32 000	3	335 650	26
Venezuela	20 800	4	406 330	44

Sources: (1) FAO, 1983e; (2) OAS, 1974.

Haiti and El Salvador have the greatest need to intensify production because of their limited land base and population density, while Venezuela and Brazil have a greater economic capacity for intensification. Fertile soils are a major factor in long-term agricultural production when a large proportion of the agricultural population does not have access to sophisticated technology, imported agricultural chemicals or an integrated service infrastructure. For Honduras, Peru and Bolivia, the alternatives are either more conservative use of good soils or continued expansion of agriculture into less fertile lands. In the absence of capital investment in agricultural chemicals, neither alternative has the potential to yield major increases in production or improvement in economic well-being.

Opening up new lands in the humid parts of the region is a costly operation, where only one hectare in fifteen can be expected to be even moderately fertile. The failure of the massive Trans-Amazonian Highway settlement project in Brazil was closely linked to the limited areas of fertile soils and the cost of inputs, services and marketing for farmers scattered along thousands of kilometers of road. Had settlement followed rivers rather than a line on a map, a much higher proportion of good soils would have been encountered at considerably lower cost.

It is estimated that 6% of the Amazon Basin has soils of moderate fertility (Sanchez, 1982). This 32 million hectares is roughly equal to the arable land base of Peru, but is spread over a 484 million hectare area, mostly in alluvial deposits of limited extent. 84% of the (excluding sandy soils) has a high nutrient status per hectare if the minerals contained in the living biomass are included. Table 5 shows the various categories of soil.

The results of more than a decade of controlled experimentation in the upper Amazon Basin in eastern Peru show the productive potential of relatively infertile, but well-structured tropical soils under intensive management (Sanchez, 1982). Yurimaguas lies just on the humid side of the PET/P Unity Line in the Life Zone diagram (Fig. 1) marking the division between dry and humid climates. Average yields were between 2.3 and 3.5 tonnes per hectare for rice, corn, soybeans and peanuts, with a combined yield of 7.8 tonnes per hectare over a year of continuous cropping. Three tonnes of lime were applied every three years, 80-100 kg of nitrogen to corn and rice, and 25 kg of phosphorous, 80-100 kg of potassium and 25 kg of magnesium to each crop. Traces of copper, zinc, boron and molybdenum were applied to correct deficiency problems. This work demonstrates that mid-latitude crops and soil management technology can be transferred to the humid tropics. The model described closely approximates the "High Level Input" scenario of the Agro-Ecological Zones Project (FAO, 1981a).

Table 1.5 Amazonian soils

Soil groupings	Flat, poorly drained	Well-drained Slope 0-8%	Slope 8-30%	Slope >30%	Total (%)
	million ha				
Acid, infertile (Oxisols, Ultisols)	43	207	88	23	371(75)
Poorly-drained alluvial (Aquepts, Aquents, Gleysols)	56	13	1		70(14)
Moderately fertile, well-drained (Alfisols, Mollisols, Vertisols, Tropepts, Fluvents)	0	17	13	7	37 (8)
Very infertile, sandy (Spodosols, Podzols, Psamments)	10	5	1		16 (3)

Source: Sanchez, 1982.

Such intensification might be an alternative to the prevalent process of tropical forest decapitalization, resulting in the conversion of land to poor pasture.

"Primitive" dooryard gardens (Denevan, 1984) and modern approaches to agroforestry are designed to imitate the mineral cycling and conservation of the humid tropical ecosystem (FAO, 1984b and NRC, 1982). This moderately productive alternative has the advantage of being adaptable to a wide range of ecological conditions and levels of input. Such systems rely on long-cycle crops. Multiple cropping of annuals requires almost three times the fertilizer, pesticide, fuel and labour inputs required for one grain crop in the mid-latitudes. Total yield is comparable if not higher in the mid-latitudes based on only one crop per year because of the longer day and lower night-time respiration.

Longer-cycle crops, including cassava and plantains, produce more calories per hectare per year than do corn or other grains, even when double cropped, because they capture solar energy continuously over a longer period. The forest products industry uses only a fraction of the species found in the tropical forests. More benefits can be derived from much of the tropical forest in situ in the form of medicinal plants, animals, water conservation, genetic research and recreation (Myers, 1983).

2. FOREST RESOURCES

The Latin America and Caribbean Region has the greatest area, volume and diversity of forest resources in the world. The American Tropics account for 56.5% of the estimated 1 200 million ha of global tropical forests (FAO/UNEP, 1981). The continent is favoured with a landscape and climate eminently suitable for forests, and a relatively low population density, generally concentrated outside the most extensively forested areas.

The rate of deforestation in the region is similar to that in Africa and Asia. However, because of the larger standing volume, the actual extent of forest loss is 4 million ha per year in Tropical America (Annex Table 6) compared with 2.2 and 1.3 million ha per year in Asia and Africa respectively. During the last several decades, deforestation has accelerated in the region; and the massive scale of deforestation in Brazil has attracted worldwide publicity. While shifting cultivation, fuelwood cutting and high-grading timber operations have contributed to forest depletion, by far the most destructive activity has been extensive cattle ranching.

Amazonia, the sparsely-inhabitated interior of South America, contains more than half the tropical forests in the hemisphere. This creates a statistical distortion of forest resources in the region. If the existing area and growth increment of forests were accessible to the population on a per caput basis, they would have abundant resources. This however is not the case. Where areas are densely populated, forest resources are most depleted. The destruction of watershed forests is threatening urban water supplies, energy generation and irrigation. Wood for fuel and construction comes from increasingly distant sources. Peru, with its extensive, but relatively inaccessible Amazonian forests, derives 20% of its sawn wood from more accessible field border plantations of eucalyptus in the temperate Andean highlands. Virtually all the wood used on the populous coast is either hauled over the Andes at great cost or imported.

2.1 BROADLEAF FORESTS

Of the 81 million hectares of temperate broadleaf forests, 74% are in Argentina, 25% in Chile, and a small area in Uruguay (Annex Table 7). Some 93% of tropical broadleaf forests are found in South America (48.5% in Brazil alone). Contiguous areas of the Amazonian forest in Brazil, Bolivia, Peru, Ecuador and Colombia constitute about 75% of the 654 million hectares of tropical broadleaf forest in the hemisphere. Much of this area, with low population density and poor transport and industrial infrastructures, is inaccessible for practical economic purposes. These forests are burned to make way for agriculture and cattle or reserved for timber valuable enough to justify transportation to distant markets.

In Brazil huge concessions were given in the 1960s for the establishment of cattle ranches with resultant deforestation often by shifting cultivators.

In contrast to the rest of mainland Latin America, Belize, Guyana, Suriname and French Guyana have a large proportion of dense or open forests. The absence of a strong cattle-ranching tradition among the Amerindian, African, Asian and European culture groups in these countries is a significant factor in limiting pressure on forest resources. Other factors are the low population density concentrated on the coast, poor soils in the interior and poor communication facilities.

The percentage of forest cover (dense and open) varies from 1.73% in Haiti to 98.57% in French Guiana (Annex Table 8). Mexico, some of the lower Caribbean islands, Peru, Bolivia and Chile have extensive unforested areas because of dry climate or high elevation. In Peru, for example, 12% of the country is coastal desert and much of the higher Andean sierra which comprises 28% of the national territory, is unforested. The 55% of the country with forest cover is concentrated in Amazonia where population density is lowest. For Central America, the larger Caribbean islands and most of South America, the difference between the actual forest cover and the potential of around 90% is due primarily to clearing for other uses. Haiti and El Salvador are extreme cases of deforestation.

In the western llanos of Venezuela a decline in population caused by virulent malaria and social unrest resulted in land abandonment and forest recovery (Hamilton, 1977). In Trinidad, extensive areas of abandoned cacao plantations have reverted to secondary forest. In lowland Bolivia, Ecuador, Colombia, the Yucatan/Tabasco area of Mexico and Belize, thousands of hectares of pre-Colombian ridged fields in poorly drained areas reverted to forest (Denevan, 1970). Machu Picchu and Tikal are striking examples of settled areas which have returned to tropical forest. These however, are exceptions; the tendency is for forested areas to be converted to other uses.

In insular Caribbean, there are virtually no forests left. Less than 2% of Haiti remains forested. Only 13% of the Dominican Republic's forest cover remains. The border between Haiti and the Dominican Republic is visible today from the air because of the barrenness of the Haitian side. If deforestation and overgrazing are not curbed, the political boundaries between these two countries will become indistinguishable (JRB, 1981)

On rugged islands such as Dominica, forested areas remain due to the topography. Periodic hurricanes in the Caribbean area cause severe damage and have been responsible for the loss of much marketable timber. They do not, however, seriously affect the capability of the forest to recover its structure or watershed management functions. Hurricanes striking the largely deforested and eroded watersheds in the Dominican Republic have resulted in unprecendeted rates of reservoir sedimentation.

Where forested alluvial and volcanic soils are cleared for intensive agriculture, the development benefits are clear and justifiable. Much of the better land has been under agriculture for centuries. Unfortunately most of the land cleared in recent decades has been marginal for agriculture due to high erosion potential and lack of fertility or drainage.

The most common pattern of deforestation throughout the region is the successive clearing of isolated forests until the agriculture frontiers of adjacent valleys coalesce leaving the intervening mountains bare. The mountain ranges between the Cauca and Magdelena Valleys in

Colombia and the Azuero Peninsular in Panama are typical examples. The immediate effect of clearing forest land is a scarcity of fuelwood, construction material, game and other non-wood products of the forest. These products can, at a cost, be replaced. More difficult to replace is upper watershed forest cover, the loss of which has detrimental effects on water supply and control structures for irrigation and energy generation.

2.2 UNDER-UTILIZATION OF TROPICAL FORESTS

The tropical broadleaf forests of Amazonia and elsewhere in the region are not homogeneous. Not only is there a high diversity of species per hectare (often 100 or more), but also a varying mix of species and growth forms, according to rainfall, elevation, soil and drainage. The rational use of tropical forests is limited by their perceived abundance. There is so much wood available that there is no incentive to practise sustained yield management.

Tropical forests have a gross volume of 155 cubic metres/ha, but the harvest seldom exceeds 5 to 15 cubic metres/ha. In Bolivia, 95% of the wood harvested comes from only 10 species; in Peru, 70% from 8 species; and in Panama, 90% from 10 species. Only in Costa Rica has there been an increase in the species used (between 1960 and 1980 from 45 to 120 species). The low rate of utilization is generally due to a combination of the following factors:

1. Abundance of wood from a few species of known characteristics and market value.

2. Lack of information on less common species.

3. Lack of government-supported programmes to market less common species with desirable characteristics.

4. Scarcity of roads, river transport and infrastructures resulting in a lack of incentive to realize the full potential of forests.

5. Lack of practical knowledge of sustained-yield management practices. At present, crop cultivation provides greater short-term economic returns than traditional methods of forest utilization. However, sustained-yield management of natural forests, enrichment planning and large-scale reforestation have the potential to provide higher, long-term economic benefits.

These factors combined with the geographical isolation of much of the forests make it economically rational for individual land owners to cut and burn a forest containing valuable tree species in order to plant crops or grass.

Impediments to the rational management of forests are the land tenure and concession conditions affecting forest use. In most countries of the region, forests are considered the property of the State which grants concessions for short periods only. Without security of ownership, there is no incentive to manage a forest for regeneration or replanting. The duration of concessions should coincide with the time required for a forest to regenerate to marketable size, otherwise it is easier to obtain a concession to another parcel of virgin forest.

2.3 MANGROVES

Mangroves form extensive homogeneous forests covering an estimated 5.8 million hectares in Tropical Latin America (Table 2.1). They occur in the sheltered waters of bays, coastal lagoons and river mouths where tidal action creates a salinity regime that excludes other species. These conditions are found under widely varying climates ranging from desert fringes in north Peru and the Guajira in Venezuela to the wet forest fringes of the Colombian Choco and the mouths of the Amazon and Orinoco. Timber production takes place on alluvial substrates near river mouths where fresh and salt water are mixed and there is an ample nutrient supply. Black mangroves 40 metres in height and 1 metre in diameter are common in the San Juan river esturary north of the Orinoco mouth in Venezuela. Mangroves of similar size are found in north Ecuador and the Choco of Colombia, although the Ecuadorean stands have been largely cut over.

Table 2.1 Mangrove areas in Tropical Latin America

Country	Area	Country	Area
Mexico	660	Cuba	400
Costa Rica	39	French Guyana	55
El Salvador	45	Haiti	18
Guatemala	50	Dominican Republic	9
Honduras	145	Surinam	115
Nicaragua	60		
Panama	486	Other Caribbean countries	597
Central America and Mexico	1 485	Bolivia	
		Brazil	2 500
Belize	75	Colombia	440
Guyana	150	Ecuador	235
Jamaica	7	Paraguay	
		Peru	28
Trinidad and Tobago	4	Venezuela	260
CARICOM	236	Tropical South America	3 463
		Tropical America	5 781

Source: FAO/UNEP, 1981.

The dominant species of economic importance is the red mangrove, (Rhizophora) on sites receiving daily tidal flushing; and the black mangrove (Avecennia) inland where salinities seasonally may reach 60 to 80 parts per thousand (Odum, 1982). Avecennia forests, isolated from frequent tidal flushings have a particularly important function. In Florida a pulse of high quality organic matter from Avecennia stands enters the estuary at the beginning of the wet season (Twilley, 1984). Similar pulses of energy may have an important function in estuarine production in the rest of Latin America and the Caribbean.

Although temperate South America does not have very important mangrove sites, it does have swamps and seasonally inundated riparian areas. Argentina's palm-forest swamp in the plain between Rio Pilcomayo and Rio Paraguay has many similarities with tropical mangroves because of special edaphic conditions (hydromorphic soils).

In a number of countries, forest clearing is a prerequisite to granting title, a strategy to encourage agriculture and not speculative land holding. Managing a natural forest on a sustained basis is not considered to be valid use of the land. In practice land capability maps and land use plans view forestry as a transitory use of the land. There are few functioning tree farms or national forests managed exclusively for timber production.

An estimated 99 million hectares of land of the region is classified as "forest fallow", i.e., forest that has been cleared, burned, cultivated and then abandoned to natural succession. Most of the forests of the region have been cleared at some time in the past. Shifting cultivation accounts for 35% of all deforestation in the region (Table 2.2) Where population density is low, farmers (predominantly Amerindian), leave land in forest fallow for twenty years to ensure recovery of nutrients. Fallow periods of even twenty years do not permit the regeneration of commercial timber, only the accumulation of nutrients by second growth to a level approaching that of the original forest. Where population pressure is high or soils are fertile, a fallow of only a few years prevails. All too frequently shifting cultivation is followed by pasture maintained by annual burning.

Table 2.2 Estimated deforestation resulting from shifting agriculture (1981-1985)

Sub-region	Shifting cultivation in rotation with successional forest	Other forms of deforestation	Total deforestation
	'000 ha		
Central America and Mexico	405	597	1 002
CARICOM	8	6	14
Other Caribbean countries	-	11	11
Tropical South America	1 126	2 186	3 312
Tropical America	1 539	2 800	4 339

Note: Data for temperate South America are not available.

Source: FAO/UNEP, 1981.

There are only a few examples of tropical forests that have homogeneous species composition: these often occur on moist sites and in the transition between estuarine ecosystems dominated by mangroves and upland forest. They include Pterocarpus officinalis, Carapa guianensis, and Mora species in northeast South America and Prioria copaifera, Campnosperma panamensis, and Iryanthera joruensis in the isthmus area between Costa Rica and Colombia. Mora excelsa is managed intensively in Trinidad and Tobago. Harvests from these forests are often higher than the average from heterogeneous upland forests. With the exception of Trinidad and Tobago, these forests are not managed in the region.

Mangrove forests in the Western Hemisphere are exploited for construction material, fuelwood and tannin. On the San Juan river north of the Orinoco, Venezuela has a sustained-yield management programme of strip cutting to harvest red and black mangrove for poles, sleepers, beams and parquet (Hamilton & Snedaker, 1984). However, by far the greatest value of the mangrove is not its timber, but the contribution of the mangrove ecosystem to the productivity of estuarine and in-shore marine fisheries. Crabs, oysters and other shellfish are harvested from mangrove areas and an estimated 80% of the commercial and sports fishing species pass part of their life cycles in the mangroves.

Mangrove forests are open systems receiving water and nutrients from both land and sea. This makes them particularly vulnerable to human activities, such as port and road construction, agriculture and mariculture schemes and waste disposal. In Columbia, a coastal highway along the Caribbean interrupted tidal exchange between the sea and lagoons near the mouth of the Magdelena River causing loss of mangrove and fishery resources. Efforts to convert acidic mangrove soil to agriculture are not generally cost effective, as was found with the Cano Manano scheme at the Orinoco mouth (Pannier, 1979).

By far the most wide-spread threat to mangrove ecosystems is the conversion of mangrove and saline areas into diked pond complexes for the rearing of shrimp. In Ecuador, this highly lucrative activity has resulted in the conversion of some 60 thousand hectares of inter-tidal land to ponds. Pond construction either displaces mangroves or affects the movement of fresh and salt water and nutrients through the ecosystem. This activity is becoming important in Panama, Brazil, Colombia, Peru and elsewhere.

2.4 CONIFEROUS FORESTS

The total area of productive coniferous forests in the region is approximately 15.2 million hectares (Annex Table 9). In the Northern Hemisphere, Mexico, Honduras and Guatemala, have the largest areas of conifers (mostly pine), with important stands in Belize and Nicaragua, the southern-most extent of their range. This area accounts for almost 14.2 million hectares.

Other species in the region are: Pinus sp. (1.7%) in the Caribbean (mainly Dominican Republic and Cuba), 1.7% in the declining Araucaria forests in Brazil, 1.2% Podocarpus sp. in the Andean area, and Araucaria sp. and some Podocarpus sp. in Argentina and Chile. South American conifer forests do not readily regenerate after cutting and are replaced by other species in natural succession, or the land is converted to other uses such as pasture, or pine and eucalyptus are planted.

Because of the poor, acidic soils associated with pine forests in Mexico and Central America, the lands are not in high demand. The more open pine forests cannot be cut and burned by shifting cultivators for nutrients as can broadleaf forests. The area of pine forests has not declined as much as has tree density and wood volume. In Honduras, for example, the volume of pine timber declined from an estimated 48 million to 28 million cubic metres between 1964 and 1980 without appreciable loss in area. At lower elevations in Central America, pine forests colonize abandoned land, remaining dominant as long as fire prevents succession of broadleaf forest in areas of pre-Colombian settlement.

Accessible pine forests with a satisfactory growth rate are of economic importance because of the ready acceptance of pine timber on national and international markets. In Mexico and Central America the volume of broadleaf wood is 2.7 times that of conifers, yet production of wood from conifers is 3.2 times that from broadleaf forests. Of the 241.5 million board feet of lumber exported from Honduras, 237 million were pine. The areas covered by the two types are essentially the same (JRB, 1982)

The decline in pine timber volume is attributed to several causes. Forests are owned and exploited by the State and the people living in pine forest areas have no economic stake in the resource. Where communities (as in Mexico) or individuals have timber rights, the State forestry enterprise pays low stumpage fees which acts as a disincentive to efficient management and promotes wasteful logging practices. On the world market the quality of Honduran pine is superior to that from Florida, but stumpage paid for the former is only 20% of the US rate (RJB, 1982).

Efficient logging and milling could cut by half the amount of land needed to achieve current production levels. Controlled burning is essential in natural pine forest management, but inefficient use has reduced regeneration in both logged and unlogged areas with resultant reduction in future timber volumes. Annual burning to maintain pasture prevents seedlings from reaching a fire-resistant size. This, coupled with overgrazing and marginal agriculture, further degrades forest resources.

The slow growth and regeneration of South American conifer forests prevent them from being treated as Northern Hemisphere pines. Technical limitations can be overcome by the adoption of practices such as fire management, thinning, and efficient handling and milling. The rural population must be associated with the management of the forest and its exploitation and industrialization, otherwise, their use of forest land for grazing and marginal agriculture will conflict directly with the aims of forestry.

2.5 FUELWOOD AND CHARCOAL

Fuelwood and charcoal production in the region is estimated at 253 million cubic metres per year, 80% of which is used for domestic cooking and heating. This is three times greater than the production of lumber and plywood. Production figures are approximate because only part of the fuelwood and charcoal enters the formal economy and much is not cut on land classified as productive forest (FAO, 1983f). For the poor who depend on fuelwood, there are few economically attractive alternatives. During the period of high petroleum prices, small industries (e.g. brick factories, bakeries, sugar mills) tended to return to the use of fuelwood. As urbanization increases, per caput consumption of fuelwood decreases. However, because of population growth, total consumption has remained constant and, except for the petroleum-producing countries, wood remains a major source of fuel in the region.

In contrast to the rest of the region, Brazil is a large consumer of charcoal for industrial purposes. Iron foundries and steel mills use some 38 million cubic metres of charcoal (20% of the estimated value of fuelwood), 55% of which comes from low cerrado forests, 16% from dense forests and 29% from eucalyptus plantations. It is estimated that plantations supplied about 47% of the demand in 1985.

2.6 PLANTATIONS

Large-scale commercial planting of trees is a phenomenon of sub-tropical and temperate Brazil, Argentina and Chile, where pine and eucalyptus are planted for paper pulp, timber and industrial charcoal. Apart from Brazil and Chile, the rate of reforestation is low: approximately one hectare for every 33 hectares deforested.

Some of the earliest plantations in the region were Eucalyptus globulus in the Andean area in the middle of the last century (Dickinson, 1969). The Paulista Railroad Company established fuel plantations (mostly eucalyptus) early in the century along its rail lines. The extent of planted forests in 1951 was estimated to be no more than 40 thousand hectares. Plantations increased substantially in various countries as a result of private initiative, government programmes and international technical assistance, particularly in Brazil, Argentina, Chile, Colombia, Cuba, Venezuela and Peru. The number of plantations has grown by 44% since 1976.

FAO classifies plantations according to two types: industrial, destined for the wood-products industry, and non-industrial, for protection, conservation, fuelwood and charcoal. Brazil accounts for 58% of the industrial and 82% of the non-industrial plantations.

Elsewhere in the region, plantation forestry has not been so successful, lack of economic motivation being a major factor. Timber from unmanaged natural forests, both coniferous and broadleaf, continues to be an economic source of wood. Countries without fossil fuel resources do not have sufficient energy demand to justify fuel forest plantations. Domestic and even regional market demand for paper and wood products is insufficient to attract major industries. Where there is a potential demand, topography and climate may not be suitable for large-scale plantations or land may be already under food or export crops. Hauling wood chips or charcoal over the Andes is not economical. The economic feasibility of producing paper pulp under humid tropical conditions, far from markets, is being tested by the Brazilian owners of the Jari operation at the Amazon mouth.

Fuel forest programmes have not as yet begun to meet even a fraction of the demand. The availability of combustible woody material that can be gathered by a family greatly reduces the market for commercially-produced fuelwood. Those who are most dependent on fuelwood have little or no land upon which to plant trees nor do they have the purchasing power to buy seedlings, fencing or other inputs. With the exception of small land owners in the Andes (particularly Peru), who carry on small-scale commercial forestry, based on eucalyptus plantations, there is little evidence in the region of a tree farming "mentality" among land owners. In the Peruvian case, the primary orientation is the sale of timber for mines and for construction purposes, with fuelwood generally a byproduct (Dickinson, 1969). Experiences in Brazil show that fuelwood and charcoal can compete successfully with unsubsidized imported fossil fuels, thereby making fuelwood plantations economically feasible. Domestic fuel may best be obtained from the byproducts of commercial wood and fuel production, e.g. thinnings, slabs, branches and leaves.

Plantations for watershed protection and soil conservation have had even less success than domestic fuelwood projects, as can be seen from the small areas planted (Annex Table 11). Sites requiring protective cover are by their nature degraded, generally steep, and difficult and costly to plant. Plantation failure rates are high. People living in degraded areas generally gain some economic return from the land by grazing, which is in conflict with tree plantation. Except for the food or pay they receive for planting trees, they see little benefit in reducing reservoir sedimentation, as they use neither the resulting hydro-electrical energy nor the irrigation water. The amount of timber produced is small in quantity and of poor quality because of the nature of the degraded sites.

Eucalyptus and pine, the exotic species frequently used for conservation plantations, are not particularly effective in holding soil or in site rehabilitation because of their leaf chemistry, growth form and poor survival rate. Greater conservation benefits usually derive from natural succession occurring on sites protected from grazing and fire. Given the magnitude of the land degradation problem in the region, it would appear that more attention should be devoted to:

1. Protecting upper watersheds and water courses not yet totally degraded.
2. Engaging in wider scale land rehabilitation through protection from fire and overgrazing, rather than costly and often ineffective plantations (succession may eventually result in economically valuable forest products).
3. Promoting small-scale commercial forestry on the scattered pockets of suitable soil as a means of compensating local people for loss of access to oart of their subsistence land base.
4. Focusing on watersheds where a direct beneficiary, such as a State hydro-electric scheme, can pay the costs of conservation and of compensating the affected population.
5. Determining if land degradation is actually a symptom of lack of access of the people to productive land, credit, extension and markets.

3. THE AQUATIC RESOURCE

By virtue of its climate and topography, the Latin American and Caribbean Region is well endowed with water resources in comparison with the rest of the world. The average mean annual precipitation for the region is 1 500 mm per year - nearly double the world average. The region accounts for 31% of the world's runoff to the oceans. Averages can, however, be misleading. There are areas of unrelieved aridity and excessive rainfall, as well as areas where rainfall varies widely from year to year. The northeast of Brazil is the best known example of the latter, with periods of adequate rainfall interspersed with droughts, during which the people abandon the land and migrate to the coast. The El Nino phenomenon (defined as an invasion of warm nutrient-poor water) off the west coast of South America occurring once or twice a decade brings heavy rains to desert areas. The 1983 event brought both unusually heavy rains and extreme drought not only to western South America but around the globe.

Large watersheds draining into the ocean are mostly tropical with gentle gradients over much of their courses. They cover 84% of the region (Annex Table 12). The largest are the Amazon, Plata and Orinoco river basins. The Pacific drainage accounts for only 11% of the area with short, steep streams traversing narrow, dry coastal plains between the mountains and sea. They account for important oases of irrigated agriculture, especially in Peru. These conditions prevail from northern Mexico to central Chile with the notable exception of the Inter-Tropical Convergence Zone where humid conditions are found on the Pacific side of eastern Panama, Colombia and Ecuador. Internal drainage is found over 5% of the region, mostly in high, closed basins in Mexico, Peru and Bolivia. Annex Table 13 provides a compendium of watershed and precipitation data for countries and sub-regions (Dourojeanni, 1982)

3.1 AVAILABILITY OF WATER

That part of the hydrological cycle between the falling of rain and snow on the land and its evapotranspiration back into the atmosphere has a wide range of forms and values.

> Rain - for crops, pastures and natural ecosytems and occasionally for drinking purposes.
>
> Flowing water - for human and livestock consumption, irrigation, industrial processes, waste removal, energy production, fish production, aquatic ecosystem functions including transportation and recreation.
>
> Lakes and impoundments - drinking water for humans and livestock, limited industrial use, fish production, aquatic ecosystem functions and recreation.

Estuarine waters - fish production, mariculture, waste dispersal, ecosystem functions, including waste assimilation, timber production and recreation.

Swamps and marshes - waste assimilation and other ecosystem functions, timber and reed production, aquifer recharge and wildlife habitat.

Ground water - human and livestock consumption, industrial processes and limited irrigation.

For sustained use of water, some form of management is necessary. All uses are not mutually compatible: impoundments can drastically affect downstream fisheries; forest clearing and agriculture in the watersheds affect runoff hydrology and stream flow, sediment and nutrient load.

Some 90% of the region's population lives in tropical and subtropical areas with 500 to 2 000 mm of rainfall per year. When the efficiency of rainfall at higher elevations (low evapotranspiration) is taken into consideration, it indicates that the availability of water is not a serious constraint on the majority of the region's population. Direct uses of water include irrigation, hydroelectric generation, potable water and other urban-industrial uses, accounting for only about 3% of available water. In addition, 92% of the agricultural land and all of the natural terrestrial ecosystems depend upon rainfall (Dourojeanni, 1982, p. 230). Water not returned to the atmosphere through evapotranspiration renews groundwater supply and provides an essential input to productive swamps, lakes, streams and estuaries.

3.2 URBAN-INDUSTRIAL USE

The minimum standard for satisfying human needs is 50 litres of water per caput per day. Approximately 80% of the urban population of the region has access to potable water and sewage disposal systems, while less than 30% of the rural population is served. This disparity is correlated with the higher incidence of water-borne diseases in rural areas and is one symptom of the neglect of rural populations that encourages migration to the cities. Annex Table 14 illustrates this disparity in a number of countries in the region. The dispersed rural population generally requires less water per caput and a lower infrastructural investment because of the feasibility of septic tank waste disposal and the proximity to surface and sub-surface water.

In contrast, urban water supply can be costly, especially for poor migrants concentrated on hillsides and in peripheral slums beyond the reach of distribution systems. Water demand in large cities has far outstripped the capability of surrounding watersheds. A secondary impact of the deterioration of urban area watersheds is flooding and mud slides due to devegetation and uncontrolled urban expansion on unstable hillsides at the urban fringe. By the year 2000, over 60% of the population of Latin America is expected to be living in cities of over one million inhabitants. Costs of supplying water to these 380 million people can be expected to increase considerably.

In Mexico City over 70% of the water supply is subsidized by the State. Plans are being implemented to supply the future water needs of the city's population estimated to reach 26 million by the year 2000. Water will be pumped from as far away as 200 kilometers horizontally and some 1800 metres vertically. The construction costs and energy requirements will be enormous. Currently, water is being withdrawn from irrigation systems and hydroelectric reservoirs. Venezuela and Peru are contemplating similar systems to supply their growing capital cities.

Few cities have wastewater treatment systems adequate for their growing populations. While wastewater treatment may result in reduction of disease problems in the community served, downstream populations are often exposed to a concentration of contaminants far higher than before. Rarely are hazardous wastes from industry, mining or hospitals given on-site treatment before mixing with the domestic waste stream.

The concentration of populations in a few major urban centres is paralleled by the concentration of industry with additional water demands and often with hazardous waste problems. In drier zones, re-use of water downstream for human and animal consumption and for irrigation can result in the infection of rural people and the return of contaminated products to the city.

The Bogota River is relatively small compared to the waste steam entering it from the Colombian capital city of Bogota. A river base flow averaging 24 cubic metres per second is augmented by several times that flow of waste drawn from other river basins for urban use and eventual disposal as untreated wastewater, with resultant high levels of contamination extending for many kilometers downstream (ECLA, 1979, pp. 53-59).

The inshore waters off the intensely-used beaches of Lima, Peru, receive some 20 cubic metres per second of untreated wastewater which constitutes a health hazard to bathers and contaminates seafood.

On the other hand, agriculture can benefit from the nutrients and organic matter contained in wastewater. For example, over the last 80 years the Tula Valley has evolved a system of agriculture based almost exclusively on wastewater from Mexico City. The 44 000 hectares now under irrigation can be expected to grow as population and wastewater generation increase.

3.3 WATER FOR IRRIGATION

Less than 10% of the cropland in the region is irrigated, but the area is growing at 3.2% per year (FAO, 1983a, p. 58). Some 75% of irrigated land is found in traditional zones such as northwest Mexico, coastal Peru, the valleys of central Chile, Andean Argentina and specific sites in central and southern Brazil. The relatively small area under irrigation derives from several factors: the well-watered nature of most of the continent; the high capital and energy costs of irrigation compared to rainfed agriculture; and the lack of a cultural tradition in irrigation, such as exists in parts of Asia where lands under similar conditions are irrigated.

The rapid increase in irrigated area can be attributed to the use of suplementary irrigation in larger scale commercial agriculture and to large and small-scale irrigation projects funded by international development assistance institutions.

The Caribbean countries made the greatest progress in irrigation during 1967-1977, followed by Central America and Mexico; those three regions had rates of expansion of over 50%. Next were the Atlantic and Southern Tier regions, followed by the Andean region with an area of less than 16%. In absolute terms, Mexico (39%), followed by Argentina, Chile and Peru (9-12% each) and Brazil (8%), accounted for the most irrigated areas in Latin America (Annex Table 15).

Peru with the largest proportion (40%) of irrigated to total cultivated area in the region, is followed by Chile (22%), Mexico (18%), Jamaica (15%), Guyana and Cuba (14%), Dominican Republic (13%), Trinidad and Tobago (12%) and Costa Rica (11%). Countries with a long history of irrigation such as Peru and Chile, or widespread expansion in more recent times as in the case of Mexico, have less potential for new expansion. Increases in production from irrigated land is more likely to occur as a result of improved management of existing areas, through rehabilitation of salinized areas and more efficient use of water.

An example is the Chira-Piura project in northern Peru dedicated to the improved use of 112 000 hectares. The expansion of irrigated land on the Peruvian coast is also significant with the Olmos project in the north accounting for 150 000 hectares of new land. About 25% of Peru's irrigated land is located in the intermontane valleys of the Andes. Erratic rainfall and dense rural populations make irrigation important. An estimated 500 000 hectares of pre-Colombian terraces, some of which had been irrigated, are presently being utilized for grazing only.

Argentina's irrigated area has an importance much greater than is indicated by the amount of land occupied. Although it comprises less than 6% of the total cultivated area, irrigated land produces 20% of agricultural production. Much of this land is in the dry, subtropical north where double cropping under irrigation is feasible. Most of the potential for increasing irrigated production comes from more effective use of existing systems and rehabilitation of salinized areas.

In Brazil, 90% of irrigated land is located in the rice growing south. In the northeast, irrigation programmes in the São Francisco Valley and elsewhere are important because of the erratic rainfall and a large rural population.

3.4 WATER FOR ENERGY

While the region has developed less than 10% of its hydroelectric potential, most of the economically attractive sources are being developed. As in the case of urban water supply, the major centres of energy demand are distant from the areas of greatest generation potential.

A bias has long existed toward large projects aimed at meeting or creating urban-industrial energy demand. This has prevented adequate attention being given to the widespread potential for developing modest hydro-electric resources to benefit towns and villages isolated from the national power grid. Rural electrification can enhance the quality of life and provide the basis for a variety of small-scale industrial activities, such as food and forest product processing.

It is estimated that steep lands occupy half of the humid tropics of the region. From 20 to 80% of the agricultural population in each country live in areas with steep slopes (Posner and McPherson, 1982). This is a rough indicator of the magnitude of the population that could be served by small-scale hydroelectric development.

3.5 AQUATIC ECOSYSTEM MANAGEMENT

The quality and quantity of water for urban-industrial, agricultural and energy generation uses, as well as fisheries production, waste assimilation and recreational functions, depends on watershed management and management of the aquatic ecosystem itself.

Of equal importance to the maintenance of water quality through pollution control is the maintenance of the physical and biological functioning of a water body as it interacts with the environment (Karr et al, 1981). This involves, for example, the capacity of the system to assimilate wastes, trap sediments and continue to provide water and fish of acceptable quality downstream. The four main points to be considered in maintaining the quality or integrity of the aquatic resource are:

Flow or hydrological regime. Streams, lakes and swamps experience characteristic changes in water level which trigger plant and animal reproduction and permit the oxidation of accumulated organic material which would otherwise cause eutrophication. Mangroves and tidal marshes are heavily dependent upon both tidal exchange and fluctuating stream flow to maintain their characteristic high productivity.

Habitat structure. The presence of a variety of physical substrates such as rock outcrops, gravel, sand and mud banks, fallen trees, shallows and deep holes, living tree roots and anchored vegetation strongly affect the abundance and diversity of fish and other aquatic life and the self-purifying capability of a water body. The presence of adequate vegetative cover reduces erosion (Stream bank, gulley and/or sheet) and filters sediments and attached nutrients from the runoff.

Energy source. Aquatic ecosystems become adapted over time to different energy or food sources. The major division is between systems that generate their own food through photosynthesis (suspended or anchored vegetation) and those dependent on dissolved or particulate organic matter entering the stream from outside.

Water quality is measured by physical and chemical parameters such as temperature, dissolved oxygen, suspended solids, trace minerals, nutrients, salinity/alkalinity, and acidity. Of particular concern is the presence of toxic substances and disease-bearing organisms in water for human consumption.

The intrinsic quality of a particular body of water is determined by interaction among the other three parameters defined above coupled with the characteristics of the runoff naturally occurring from the watershed. Changes in habitat structure and flow regime caused by human activity coupled with nutrient and sediment additions from agriculture or urban areas can affect energy sources and thus fisheries production and water quality.

The following are some of the activities which result in deterioration of water resources:

Channelization. Habitat structure, flow regime and energy source are drastically affected with resultant reduction in fisheries production and increased potential for downstream flooding. The quality of water entering a channel is little improved over time due to loss of purification capability. Channelization of the lower Jubones River in Equador and in the Guanare-Masarro area in the western Llanos of Venezuela resulted in the transfer of flooding problems further downstream.

Impoundment and/or water diversion. Changed flow regime coupled with the trapping of sediments and nutrients result in major changes in downstream and estuarine productivity, salt water intrusion, and erosion of stream banks and coastal islands. A coastal highway in Colombia between Barranquilla and Santa Marta, built without adequate culverts to maintain tidal exchange, resulted in a decline in fisheries on both the Caribbean and estuarine sides of the road.

Stream bank clearing. Small areas of farm or grazing land gained by clearing, result in a loss of fisheries resources and decline in water quality locally and downstream. This is particularly critical in small and steep upper watershed streams where quality maintenance must begin. This problem is serious throughout the region.

Waste disposal. Ecosystems have an intrinsic capability to assimilate wastes. Controlled experiments in swamps and marshes have shown that these ecosystems are capable of removing large quantities of nutrients from wastewater. However, coral reefs are vulnerable to low levels of pollution.

3.6 SOME AQUATIC RESOURCE PROBLEMS

In Latin America and the Caribbean, water availability is not expected to change significantly, although by the year 2000, urban use is expected to increase by 120%, industrial use by 320% and irrigation by 70%. Several persistent water-related problems can be expected to plague development.

The continuing concentration of urban-industrial development in areas with limited water resources will impose high capital and energy costs for pumping, in addition to increasing opportunity costs as water is diverted from productive uses such as irrigation, energy production and fisheries maintenance (Scott, 1982). In efforts to decentralize urban growth and industry, high priority should be given to providing adequate water supply to locations downstream, taking into consideration the capacity of the surrounding environment to assimilate, disperse and/or re-use waste water.

Salinization, waterlogging and wasteful application are common results of misuse of irrigation water. Underpricing of water (e.g. US $1 for 1 000 cubic metres in Peru) encourages misuse. Rice is flood irrigated in Peru on porous soils and a third of the irrigated land is affected by salinization and waterlogging (Dourojeanni, 1982).

Integrated management of aquatic resources is needed to ensure optimum benefit to society. The experience of Venezuela and many other countries in the development of hydraulic resources has demonstrated the risks involved when these activities are carried out without adequate integration (MOP, 1974). In Venezuela, major capital resources were committed to the Guanare-Masparro hydro-electric irrigation and drainage scheme without either a watershed management programme or coordination with institutions responsible for the infrastructure (Dickinson, 1982).

There is a tendency among governments and funding institutions to focus on large capital-intensive water management projects. Insufficient attention is given to alternatives, often less costly, more sustainable and of higher potential. Farmers engaged in rainfed agriculture are often poor and unproductive, not for lack of water, but for lack of adequate skills and institutional support in extension, credit and marketing. It is generally more economical to intensify production on better-drained soils than to make large investments in flood control and drainage on lands already serving an economic function for forest and fisheries production. This was found to be the case in the Guanare-Masparro example referred to above and in the more widely publicized example of acid sulphate soil drainage in the Orinoco Delta (Pannier, 1979). During pre-Colombian times, thousands of hectares of poor soils were drained in Latin America using raised fields (*camellones*) without the off-site impacts inherent in large-scale drainage schemes (Denevan, 1970).

4. FISHERY RESOURCES

4.1 MARINE FISHERIES

In only a few countries in Latin America and the Caribbean is the fisheries sector a significant component of the national economy. Chile, Peru and Ecuador are important fishing nations because of their proximity to the rich waters of the Humboldt Current. The fisheries of the Pacific Coast from Mexico to Chile were adversely affected by the 1982/83 El Niño phenomenon that brought unusually persistent changes in ocean currents and water temperatures. Anchovy catches dropped to the lowest level in the history of the fishery. Mackerel, pilchard and other fish were affected in abundance and/or distribution. While total catches of most fish were lower, the persistent warm ocean temperatures off Ecuador and northern Peru resulted in record shrimp catches in 1983 (FAO, 1985).

In Ecuador, though the value of shrimp (mostly from aquaculture) now exceeds that of bananas (the traditional leading export crop), in 1983 they represented only a tenth of the value of petroleum exports. In Peru and Chile the value of mineral exports eclipses that of fishery products.

Parts of the Gulf of Mexico, the mouths of the Orinoco and Amazon, the cold waters of the South Atlantic and the Humboldt Current of the South Pacific are important areas in which production is increasing. The export value of production from the Mexican and South Atlantic fisheries is small compared to the mineral and agricultural exports of most of the countries. In both the Caribbean and the Pacific, the clear waters support a low quantity of fish per unit area with a high species diversity, a condition which does not lend itself to the development of a large export fishery.

The extension of marine jurisdiction to include Exclusive Economic Zones has given the countries of the region an opportunity to control and benefit from the exploitation of their fishery resources (FAO, 1981c. p. 106). Whether such benefits accrue from payments for fishing rights by foreign fleets or from an increase in activity by national fishery sectors, varies within the region. To varying degrees, the countries of the region are limited in their potential to fully develop their export fishery potential by the same factors limiting other sectors (CEQ, 1981, p.25). These include lack of capital, technology and industrial infrastructure.

In general, catches have increased in the region. Excluding the anchovy fishery with its wide fluctuations, the 1970s saw an increase of 150% in overall catch. Fisheries in the Pacific registered the greatest increase with the central area experiencing an increase from 0.5 million to 1.9 million tonnes (90% from Mexico and Ecuador). While the anchovy catch of Peru and Chile has dropped, the catch of other species increased by 170% during the 10-year period. In 1984, these two countries accounted for 64% of the catch in Latin America and the Caribbean (FAO, 1984f). More than half of the total catch of the region is processed into fish meal; another 25% is sold fresh or chilled and the remainder is frozen, canned or cured.

4.1.1 Domestic consumption

During 1980-82 the average *per caput* supply of fish and fish products in the region was 10.2 kg per year, with wide variations among countries. The lowest *per caput* supply was 0.6 kg in Guatemala, and the highest, 50.3 kg in Guadeloupe (FAO, 1984f). However, people living on coastal islands, tropical rivers or lakes may consume much more fish than their national average indicates.

In a region where half the children suffer from dietary deficiencies, particularly protein, it is a significant concern that so little of the fish catch finds its way into national markets (FAO, 1983b). The reasons are complex, varying among countries and cultural groups. For example, in Catholic countries fish consumption is highly concentrated during the Easter Holy Week, and little is consumed during the rest of the year. Much of this fish (mostly dried) comes from continental waters. Other reasons, perhaps more important, are the lack of adequate infrastructure and commercialization channels linking the coasts with the national urban and rural markets.

Cattle, pigs, and chickens can be transported live to the point of butchering and consumption without the need for refrigeration or other form of preservation. In contrast, fish die upon capture and begin to spoil within a few hours. Because of the distance between the point of capture and most markets, some form of preservation is essential. The cost of maintaining fish chilled or frozen during transport and prior to sale affects its competitiveness with other protein sources beyond the immediate hinterland of the fishing port. The low purchasing power of the majority of the population, both urban and rural, adversely affects the demand for fish. Cultural preferences for other meats limit the market for fish even when the price is competitive. In Brazil demand for fish is low, even in areas with chronic protein deficiency, and fish is shipped from these areas to major urban centres as a luxury food (FAO, 1983a, p.17).

The infrastructure for handling fish from catch to consumer is unique, lacking parallels or complementarity with other food handling systems. Plants to provide ice for boats, trucks and fish stalls must all function integrally. Fishing has been oriented traditionally toward an affluent export market, placing the local consumer at a competitive disadvantage.

Considerable research has gone into the production of fish protein concentrate (FPC) for human consumption. Given a reasonable bulk processing cost, FPC may be a more efficient means of increasing direct protein consumption by humans than the common practice of feeding crudely processed fish meal to livestock and shrimp. Considerable fuel and capital investment is needed to process fish meal. Feeding it to animals, often half-way around the world, is energetically and economically inefficient. Unfortunately, people (the poor included) shop for particular foods such as chicken or squid, not for protein *per se*. FPC, though not attractive as a menu item, offers considerable potential as a processed food additive for school lunch programmes and other institutional uses or emergencies.

4.2 MARICULTURE

Shrimp mariculture has brought an economic boom to the coastal zone of Ecuador and has precipitated major national and transnational investments in Ecuador and elsewhere in the region. Shrimp mariculture began in Ecuador in 1968. Production from ponds and trawlers in 1975 amounted to less than 6 000 tonnes. In 1983, the value of shrimp surpassed that of the leading export crop, bananas (an estimated 36 000 metric tonnes, predominantly from ponds) worth some 150 million dollars.

Ecuador has near ideal natural conditions of climate, substrate, tidal range, freshwater mixing, and nutrient input from both uplands and marine upwelling for the rearing of penaeid shrimp from wild post larvae. The small post larval shrimps are caught in fine mesh seines and dip nets and sold to shrimp farms. To encourage rapid shrimp growth, heavily subsidized diesel fuel is used to pump water of suitable oxygen content, temperature and food content from estuaries. Management pratices range from solely changing pond water by pumping, to fertilization to stimulate primary production, while the most intensive farms feed concentrate to the shrimps. Production ranges from 275 to 2 270 kg per hectare of whole shrimp per year based on 2.2 cycles per year (McPadden, 1985). Other countries with less favourable natural conditions and higher fuel costs have found shrimp production less profitable.

Countries heavily engaged in shrimp culture, particularly Peru (Tumbes), Ecuador and Panama, find their production limited by lack of wild post larval shrimp, due to mangrove destruction, over-fishing, pesticide runoff, limited freshwater runoff and changes in seawater temperature. Large-scale shrimp farming is so new that variations in seed supply are not yet understood. Hatcheries are not capable of meeting more than a fraction of the demand and fish farms are paying up to US $10 per thousand.

In the dry season of 1984, the scarcity and high cost of larvae resulted in an estimated 60% of the ponds in Ecuador and Peru not being seeded. Six larval shrimp hatcheries are now entering production and another 14 are being developed in Ecuador. Other nations of the hemisphere are seeking to secure their post-larval supply by establishing hatcheries. Most of these hatcheries are dependent on wild-caught gravid females until such time as technology for economical closed-cycle reproduction of penaeid shrimp is available. Ralston-Purina in Panama and a company in Ecuador produce Penaeus Vannamei post larvae using proprietory technology.

4.3 ENVIRONMENTAL IMPACT OF FISHERY ACTIVITIES

The most widespread impact of fishery sector activities is through excessive fishing of relatively few species. Catches in excess of recruitment drive populations to levels so low that recovery is uncertain, and irreversible changes in food chains may occur. This is a problem with estuarine fish and shellfish, which are particularly vulnerable to over-exploitation. Marine fisheries fail to recognize long-term changes and cycles in the abundance of different species. Examples include the collapse of the Pacific sardine fishery in the 1950s and the Peruvian anchovy fishery in 1971, with subsequent fluctuations exacerbated by El Niño events. Fishermen are often not aware of other species which may be on the increase.

The Caribbean with its high diversity and low individual species populations is particularly vulnerable to intensive fishing. A notable example is the relentless pressure on tropical lobsters, conchs and snook

(Centropomus). Though these species are unlikely to become extinct, their value to artisanal fishermen and the economies of small islands has been severely decreased.

In the Caribbean, Atlantic and Pacific, sea turtles, primarily the Green and Ridley, are threatened throughout their ranges, due to excessive capture at sea and on nesting beaches, robbing of eggs, habitat destruction and inadvertent drowning in the nets of trawlers. Many dolphins and porpoises are killed in the same manner. Loss of some nesting populations appears to be permanent. Rational turtle exploitation could provide a source of protein to coastal people in some areas. However, sea turtles cannot withstand fishing pressure to meet a world demand. Unlike many fish food chains, the decline of sea turtle does not result in an increase in another species. Other than the sea turtle, there are no known users of potential food value of the extensive shallow water grass beds in the tropics and subtropics.

Shrimp trawling and farming have a notable impact on other components of the fisheries sector. Trawling operations, through mechanical dislodgement, adversely affect bottom habitats, such as seagrass beds. The discarded by-catch of juvenile or otherwise unmarketable fish may often surpass the quantity of shrimp caught. Of greater significance is the loss of estuarine productivity caused by expanding shrimp pond operations in mangrove areas of the hemisphere.

The largest extent of ponds is in Ecuador, where some 75 000 hectares have been permitted and an estimated 60 000 hectares have actually been constructed (McPadden, 1985). About 20% of the ponds are in areas previously covered by mangroves. Mangroves are also affected by interrupted freshwater runoff and tidal circulation patterns. Most ponds have been built in salinas (salt flats) where construction costs less, but mangroves are being destroyed at an increasing rate for lack of other land.

Countries with similar coastal conditions are seeking to emulate Ecuador. These include Panama, Venezuela, Colombia, Mexico, Brazil and even Peru, where a small mangrove area is found across the border from Ecuador. Shrimp producers hope to establish hatcheries and thus become independent of the fluctuating and costly supply of wild-caught post larval shrimp. This eventuality poses both a threat and an opportunity. Once shrimp farmers become independent of the estuary for post larval shrimp, a strong argument for mangrove protection will be undermined. However, with a reliable source of post larvae, intensification on less land will be feasible.

While shrimps represent a foreign exchange source, other finfish and shellfish are important sources of food and income to coastal people in mangrove areas of the region. At one time the inter-tidal zone was considered a common resource; now any land potentially suitable for a shrimp farming concession is worth much more than prime farm land. As a result, effective possession of coastal land and its resources has passed into the hands of a relatively small number of entrepreneurs.

Detritus from the mangrove ecosystem is an important element in estuarine food chains. In the Gulf of Mexico it has been found that some 80% of the species of importance to commercial and sports fishing pass a critical part of their life cycle in the estuarine environment which includes the mangrove (Odum, 1982). Unrestricted expansion of shrimp farming can adversely affect artisanal fishermen, offshore shrimp trawlers, users of wood and tanbark, and tourism based on wildlife and sports fishing.

Some government policies, especially those aimed at increasing exports, result in over-exploitation of fish. For example, on the northern coast of South America, licences are generally given not as a means of imposing quotas or restricting fishing, but as a means of increasing government revenue from foreign vessels. As a result, the shrimp populations on the coast of Brazil and Guyana have drastically decreased. Similar over-exploitation of the abalone and sea urchin off the coast of Chile has prompted the Government to impose strict measures against their capture and to close fishing operations in certain seasons.

4.3.1 Environmental impact from other sectors

Because of the importance of coastal waters, it is necessary to examine how other development activities affect productivity. The coastal zone is a focus of urban-industrial activity, transportation, petroleum exploitation, processing and agriculture. Impacts tend to be of two kinds: dramatic events such as oil spills and outbreaks of human illness due to viral or toxic contamination; or more subtle, chronic forms of degradation. The latter have more far-reaching consequences for fishery resources, and are frequently cumulative, with multiple origins and effects. Most significant are urban-industrial pollution, pesticide runoff from agricultural lands and water diversion. The juvenile forms of marine life found in coastal waters are particularly vulnerable to pesticides and to changes in salinity gradient caused by the diversion of fresh water for irrigation, energy production or as a result of blockage of flow by road or dike construction.

4.4 INLAND FISHERIES

Freshwater fish of the region, though only 5% of the marine catch, are important because they are consumed directly, generally at a short distance from the point of landing. Therefore there is limited spoilage and low energy requirements. Prices are low and accessibility to the resource high because of the low cost of fishing equipment. Many fish are caught and consumed by families without the catch being entered into formal trade or production statistics.

Freshwater catches vary widely from country to country depending on size and extent of lowland river system (Annex Table 16). Brazil, with its extensive Amazonian and Parana River systems, has by far the largest catch.

The three major aquatic systems in the region are: rivers and streams, lakes, and man-made reservoirs. Rivers are the most extensive source, occurring in all climatic zones from over 4 000 metres elevation to sea level. The most productive are the floodplain rivers found in the tropical lowlands of the Amazon, Orinoco and La Plata drainage basins. Less extensive, but locally important, are the rivers of the Pacific lowlands of Panama, Colombia and Ecuador and the larger rivers entering the Gulf of Mexico and the Caribbean in Mexico and Central America.

Lakes vary depending on basin characteristics, elevation and latitude. Low elevation lakes such as those of Nicaragua, Honduras and Guatemala tend to be more productive.

The number and extent of reservoirs in the region has increased due to hydro-electric, irrigation and flood control projects. Small reservoirs at high elevations, stocked with exotic fishes, have added to the fishery resource as well as serving their primary purpose of energy generation. Larger, lowland tropical reservoirs have generally had a negative overall effect on the fishery resource when losses to the riverine and estuarine fisheries are taken into account. Reservoirs in Amazonia do not support the diverse fisheries characteristic of the rivers and sometimes become dominated by piranhas (Serrasalmus sp.) (NRC 1982).

Impoundments are a major threat to the productivity of lowland rivers and their estuaries. All the organisms associated with a riverine system, including fish, are adapted to the particular set of fluctuating conditions that characterize that system. Dams modify the flow regime (hydro-period) and, in the case of irrigation projects, the amount of water available for productive activities downstream.

The Brokopondo hydro-electric reservoir in Suriname went through a common sequence of changes after the dam was built. The dam was closed and the river flow reduced to the volume coming from the immediate coastal plain only. The tremendous quantity of nutrients released from the flooded forest resulted in a massive bloom of aquatic weeds. Once the nutrients were incorporated in the sediments or washed downstream, the reservoir reflected the impoverished nutrient status of the granitic shield area of its watershed. The reservoir is poor in any kind of aquatic life. Fluctuating water levels prevent the growth of overhanging trees which serve as a source of food including detritus, fruits and insects falling in the water. The dam prevents upstream migration of fish. Downstream of the dam, the steady release of water has eliminated a fish population dependent for food and reproduction on the seasonal flooding of forests adjacent to the river. Other lowland dams in the region have suffered from similar problems.

In the western llanos of Venezuela, a barrage of only a metre high to divert a small portion of the flow of the Guanare River for irrigation purposes, decimated the upstream migration of Coporo (Prochilodus sp.), a fish of importance in local diets. Higher dams interrupt the migration essential for the survival of some species. Dams built to reduce downstream flooding in the same area of the Llanos have prevented fish from reaching the rich food sources in seasonally-flooded areas. Flooding can be alleviated by constructing relief channels parallel to the main channel without damaging the fisheries or the cattle grazing system in which animals consume grasses which appear as flood waters recede (Dickinson, 1982, p. 324). Elsewhere in the Llanos, projects have been carried out to enhance grazing and fishery productivity by constructing dikes to retain and slowly release flood waters (Welcomme, 1979, p.237).

From central Mexico to Chile no large native carnivorous fish are found at high elevations (or latitudes). Exotic trout and large-mouth bass have been introduced into lakes and rivers with varying success. Bass introduced into Lake Atitlan in Guatemala virtually eliminated the smaller native fish which local people used as a source of protein. On the other hand, rainbow trout introduced into Lake Titicaca in 1928, have not affected the dominant local species (Orestias ispi). In 1982, 94% of the catches from the lake were Orestias spp. (FAO/UNDP, 1982). In general, it is difficult to estimate the impact of introduced species on local fauna because of the absence of reliable long-term data and because fish populations (as well as conditions of habitat) fluctuate naturally from year to year.

In 1984, FAO collaborated with the International Council for the Exploration of the Sea (ICES) and the European Inland Fisheries Advisory Commission (EIFAC) in setting up an Interntional Code of Practice for the Introduction of Freshwater Fish, in order to help reduce the spread of diseases and mitigate any negative impacts on local fisheries of the introduction of exotic species.

Deforestation, destructive agricultural practices and accompanying erosion coupled with loss of stream bank vegetation and channelization have resulted in significant loss in riverine fishery production. Rivers in these deforested watesheds have accentuated hydro-periods characterized by rapid and often violent runoff during rainy seaspms and correspondingly lower flows during dry seasons. Excessive sedimentation linked to rapid runoff reduces habitat diversity by filling pools, covering gravel beds and suppressing in-stream plant growth. Stream bank clearing and channelization results in additional erosion and habitat loss. Low flow and loss of habitat are the major factors in fisheries loss due to poor watershed management (Karr, 1981).

The sheer magnitude of the marine environment and the large size of fish populations reduces vulnerability to immediate effects of overfishing and other destuctive human activities. In contrast, inland waters, limited in extent, are often surrounded by intensive human activity. Around Mexico City, Bogota and Sao Paulo, where the base flow of rivers is mainly made up by waste water, fish have been virtually eliminated. The Mantaro, a major Andean river in Peru, has been so polluted by mining wastes that few fish are found along its entire course. Throughout the region, fish stocks in lowland tropical rivers have been severely depleted by indiscriminate use of poisons, including pesticides, and explosives for fishing.

Generally, freshwater fisheries can be effectively managed to provide food for the population living in the immediate vicinity of a lowland river. The larger and more productive the river, the larger the sustainable yield. However, when inland waters are exploited intensively to supply large urban markets, collapse of the fishery is almost inevitably rapid (Dickinson, 1974).

4.6 AQUACULTURE

Unlike many cultures of Asia, the pre-Columbian cultures of America had no significant tradition of aquaculture, nor did the Europeans who came in the fifteenth century. Today, most countries with cool highlands have trout hatcheries for restocking. A number of these operations date back to the 1930s. The Cerro de Pasco Copper Corporation introduced trout in Peru in the 1920s. Small trout culture operations supply hotels and restaurants, but is generally a minor activity. The costs of production preclude trout from being a source of protein for poor people, but there is some export potential because of year-round growing conditions in the high tropics. Tilapia sp., carp and limited numbers of various other native and exotic species are raised in the countries of the region, but their culture is largely for demonstration purposes. It was not until the advent of commercial penaeid shrimp culture that aquaculture in the hemisphere became a significant activity.

Aquaculture for domestic consumption faces many of the problems of wild fish in terms of refrigeration, transportation and acceptance by people not accustomed to eating fish. In the case of unfamiliar exotics such as carp, acceptance is even more difficult to achieve. In the extensive lowland areas of mainland Latin America, including the Caribbean coastal plain, and the watersheds of the Orinoco, Atrato, Guayas, Amazon and La Plata, well-managed floodplain river systems are capable of producing fish at a lower cost than under large scale aquaculture (FAO, 1983c, p.9). Such fisheries are inherently seasonal (Wellcome, 1979). Inland fishery production, whether from aquaculture or fishing, is predominantly for the domestic market. As such it is constrained by the limited purchasing power of the consumer. Large-scale aquaculture requires costly pumping equipment, and feed manufactured from commercially-produced agricultural products, even fish meal.

Small-scale aquaculture (0.1 to 0.5 hectares), offers a potential for highly-localized aquaculture based on crop residues, and household and animal wastes. When using detrital feeding species with low oxygen requirements, pumping of large quantities of water is not necessary. Such systems lend themselves to areas of the humid tropics outside the floodplains and to other areas served by irrigation networks. Technology for the raising of fish with minimal purchased inputs has existed for centuries in Asia. Research is needed on the reproductive biology and management of some of the promising native species in the region such as *Dormitador*, *Colossoma*, *Basilichthys*, *Prochilodus*, *Cichlasoma*, *Brycon* and *Arapaima* (FAO, 1984d). Cultural acceptance and the absence of extension assistance are the principal limitations to the success of small-scale aquaculture in the region.

In areas of tropical Latin America above 2 500 metres there is potential for producing trout for the export and domestic luxury markets. In some areas natural productivity is high due to the nutrients contained in runoff from grazing lands subjected to frequent burning. A major advantage of the region is the year-round supply of water. Highly refined technology can be transferred directly from single season production areas of the mid-latitudes. Market acceptance for the product already exists. Many of the problems are the same as those confronted by the shrimp industry: the need to import freezing equipment and spare parts, and provide adequate quality feed, lack of skilled maintenance and hatchery personnel and lack of accessibility.

Trout hatcheries do not have the problem of reproduction of seed in captivity that plagues the shrimp industry. However, areas suitable for trout production are often more remote from ports and airports than are coastal shrimp producing areas.

5. RANGE AND LIVESTOCK RESOURCES

Livestock production from extensive rangelands or intensive pastures is a major activity in Latin America. The share of livestock and livestock products of total agricultural output is greater than 45% for several countries (e.g. Argentina, Ecuador, Colombia and Uruguay). Since 1975, livestock production in most countries has shown a dramatic increase, especially in Ecuador, Panama and Peru, where its full potential has still to be reached.

Table 5.1 Gross output of livestock and livestock products as share of total agricultural output in selected countries*

Country	Year	Gross output (%)	% change from 1975
Argentina	1982	45.1	- 7
Colombia	1983	43.9	+ 8
Ecuador	1984	45.7	+39
El Salvador	1983	14.0	+14
Guatemala	1984	33.6	+ 3
Mexico	1982	44.8	- 6
Panama	1984	36.6	+28
Peru	1983	41.0	+26
Uruguay	1982	61.8	+ 4

* In constant 1971 prices of local currency.

Source: FAO, 1985b.

5.1 RANGE AND PASTURE RESOURCES

5.1.1 Types of grazing land

The natural grazing lands of Latin America can be divided into four major types: temperate grasslands, mountain grasslands, semi-arid rangelands and hot savannas. The temperate grasslands are mostly or wholly tick-free and are not subject to excessive drought or rain. They are found in the humid pampas of Argentina, southern Brazil, southern Chile and most of Uruguay and are among the most productive grasslands in the region. The central pampas, characterized by the absence of trees, have more than 300 indigenous species of grass. They are extensively cultivated with alfalfa (lucerne), used primarily for winter fattening of beef.

The rolling pastures of Uruguay, composed mostly of perennial grasses such as Paspalum, Andropogon, Bouteloua, Eragrostis and Setaria, are considered potentially richer than the pampa, but have deteriorated due to over-use. The best rangelands produce a yearly average of 4 550 kg dry matter forage per hectare. The natural pastures contain many indigenous legumes, such as Trifolium polymorphum, which considerably increases the quality of forage. Brazil's southern rangelands are similar to those of Uruguay.

The second type of grazing land in Latin America, the cool mountain grasslands, occur in the Andean range, the mountains of Colombia and Venezuela, the upland pastures of Costa Rica and the paramos (alpine meadows) of Bolivia, Ecuador and Peru. The potential for livestock production is moderate only because of the harsh climate. The high altitude valleys and slopes are used for summer grazing, while the lower hills are used in the winter. The higher pastures have genera such as Calamagrostis, Deyteuxia, Stipia and Festuca. Below 4 000 metres elevation, all types of livetock are grazed on the mountains, including cattle, horses, sheep and llamas. Above this line there are only sheep, llamas and alpacas. The central upland plateau of Costa Rica is used mostly for cattle production.

The third type of grazing land is the semi-arid areas found in both hot and cold climates. The Patagonian region (located in southern Argentina and Chile) is a cool, arid grassland with poor grazing resources and fragile ecosystems. Hot, arid grasslands are found in northeast Brazil, the western dry pampas of Argentina and central Mexico. Semi-arid lands, used on an extensive basis for sheep, goats and cattle, can support only a low density. They are often interspersed with shrubs, cacti and thorny trees, and some pure grass steppes. The availability of water determines the degree of utilization of these grasslands.

The fourth type of grazing land is the hot savanna, primarily found in Tropical Latin America and includes the Orinoco floodplains of Venezuela, the Llanos Orientales of Colombia, the lowland areas of Costa Rica, the Amazon basin, Gran Chaco and the Cuban and Bolivian savannas. These areas have moderate to high potential for livestock production. Long dry summers necessitate investment in water development, while grain, such as Paspalum carinatum and Andropogon lateralis lose their nutritive value very quickly as the dry season starts. Many leguminous trees and shrubs provide excellent browse for ruminants.

5.1.2 Extent of grazing lands

Extensive rangelands in the Caribbean Region are limited to the larger islands (e.g. Cuba, Haiti, Dominican Republic and Jamaica), because of the intense competition between crop cultivation and pastureland. In most cases, animals are raised on smallholdings, with hay or cut forage. The most rapid development in the livetock industry in the Caribbean in recent years has been in Cuba, where the Government has adopted a policy of self-sufficiency in milk and dairy products. This involves production of dairy cows in large feedlots and heavy reliance on nitrogen fertilizers to grow suitable feed. The increasing cost of fertilizers has prompted the Government, in collaboration with FAO, to reduce reliance on imported fertilizers and to turn to the production of indigenous forage legume crops. Other countries in the Caribbean have the potential for intensification of livestock on a smallholder basis with the use of supplementary feeds, such as salt blocks, mineral additives and "protein banks" (small, irrigated, high protein paddocks grazed daily as one hour supplements)

In Latin America, livestock are raised in different types of system, ranging from smallholder activities integrated into the agricultural system (found in most of the region), to moderate holdings of mixed herds transhuming between summer mountain pastures and wintering areas, to large, extensive ranches aimed at foreign exports. Data are not available on the contribution of each type of system to the total livetock industry. Where data do exist, they mainly cover large export-oriented operations rather than subsistence-based smallholders. However, it is certain that more people are dependent on the smallholder system than on ranches. The number of smallholders is shrinking but this is probably due to urban migration rather than to the agglomeration of smallholdings into large ranches (FAO, 1986).

Annex Table 17 shows the extent of grazing lands in the region. Forest and woodlands are included because they are often grazed.

In comparison with 1974-76, most countries have increased the area of permanent pasture and grazing land by 10-20%. Exceptions are countries with a decreasing area of grazing land (Cuba, Haiti and Jamaica); countries with no change (Peru, Uruguay, Argentina, Mexico, Honduras); and those with very high increases Ecuador, Suriname, Costa Rica) (FAO, 1985). In general, decreasing grazing area is due to land being converted to cultivation and increasing area to forest lands being converted for grazing. However, these are merely generalizations. In Section 5.2. these trends are compared to the changes in livestock production, which may give a better indication of the status of the industry.

Not all cleared forests are used for grazing, some are also used for subsistence or plantation agriculture and forestry. Data on dominant land use after conversion are available for some countries (Table 5.2). In Brazil, Ecuador, and probably Colombia and Venezuela, most of the cleared land in the Amazon basin is used by cattle, while in Peru, Guyana and Suriname, it is used mostly for subsistence farming.

Table 5.2 Dominant replacement land use of cleared tropical lowand forest in the Amazon Basin

Country	Amazon forest area	Dominant land use
	(million ha)	
Brazil	280	Cattle ranching (95%+)
Peru	65	Subsistence, cash crop, cattle (15%)
Bolivia	51	Cattle, citrus, cacao, coffee
Colombia	31	Cattle, rice
Guyana	13	Subsistence
Suriname	13	Subsistence, forestry
Venezuela	13	Subsistence, cattle
Ecuador	10	Cattle (81%)
French Guiana	8	Subsistence

Source: Hecht.

5.1.3 Rehabilitation of rangelands

For several reasons, it is difficult to accurately estimate the extent of degraded grazing. Degradation is interpreted differently by different scientific disciplines; what may be degraded to a forester is not necessarily so to a range manager. To date, no attempt has been made to document all degraded lands in the region. Where studies have been made, the classification systems employed have not been standardized, thus posing problems of comparison. Finally, no permanent, long-term monitoring system has been set up on a regional scale to monitor the rate of degradation. Nevertheless, most studies conclude that cold temperate grasslands, expecially those in the Patagonian region (southern Argentina and southern Chile) are among the most fragile and degraded. Arid and semi-arid lands are also subject to high grazing pressure and deforestation On the other hand, tropical areas seem to have a high inherent resilience, although more studies are needed to test their limits.

Rehabilitation of degraded lands in the region is carried out almost entirely by afforestation programmes which have the effect (intended or not) of making the land unsuitable for grazing. Thus, the pressure on rangelands is increasing. Investment programmes aimed at improving pastures, such as are being undertaken in the tropical areas of Argentina, in Brazil and Chile, help to relieve this problem.

In recent years, range rehabilitation programmes have been integrated into afforestation activities with the aim of creating systems mutually beneficial to both livestock and forestry. Such sylvopastoral activities are carried out mainly in Brazil and Chile. Large-scale plantation of the fodder trees, Prosopis tamarugo and P. juliflora, under arid and semi-arid conditions, have the potential to improve improverished areas, with the added benefit of increasing livestock production.

Research is being carried out in many countries on different systems of pasture improvement, such as range fertilizing, range reseeding, irrigating indigenous legumes, and different methods of conserving hay. Argentina has had a long history of alfalfa cultivation. Production fell in the 1960s, mainly because of continuous cultivation which created a deficiency in essential nutrients. Since then, efforts to improve fertilizer consumption have resulted in increased yields of alfalfa. A study in Mexico showed that beef production can be increased from 160 kg/ha/year on unimproved pastures to 750 kg on improved pastures (FAO, 1986).

The Regional Working Group on Grazing Resources in the Southern Cone, which is supported by FAO, is active in conducting research on pasture and range improvement. CIAT (Centro Internacional de Agricultura Tropical) is active in collecting and preserving germplasm of indigeneous grain and legume species with forage potential. They are also involved in conducting agronomic trials on farms and in research stations, for example, the IDIAP/Rutgers/CIAT Pasture project in Panama (CIAT, 1985).

There are many constraints to the development of range and pasture in the region. Efforts are hampered by lack of financial resources, inadequate research and monitoring facilities and insuffficient trained personnel. Over the past decade, the number of trained range technicians has been rising at a rate much slower than for foresters, though the rate is somewhat faster in countries with substantial livestock industries, such as Argentina and Brazil (Beller, 1979).

5.2 LIVESTOCK RESOURCES

5.2.1 Trends in livestock production

In the decade 1974-1984, the region as a whole saw an increase of 14% in its domesticated animals (chiefly cattle, pigs, sheep and goats). Alpacas, llamas and vicunas are raised mainly in Bolivia and Peru with an estimated total population of 6.2 million (FAO, 1986). Annex Table 18 shows the distribution of cattle, pigs, sheep and goats in the region. Tropical Latin America has 55% of all livestock, followed by the temperate zone (25%). Between 1974 and 1984, almost all countries had an increase in livestock holdings. The highest increases were in French Guyana, Suriname, Guatemala, Ecuador and Costa Rica. A few countries had a decrease, notably Nicaragua, Haiti, El Salvador, Peru and Argentina.

These changes in livestock population roughly paralleled changes in area of pasture and grazing land between 1974 and 1983 (Annex Table 17). However, in El Salvador, Peru and Argentina, a decline in numbers of livestock was not matched with a change in land area, suggesting a decreasing productivity per unit area. In Nicaragua, more forest land was taken for pastures and grazing, while livestock numbers declined. Thus, a decreasing livestock density has helped relieve some of the pressure on existing rangelands. In Honduras, Mexico, Panama, Dominican Republic, Trinidad and Tobago, Cuba, Bolivia and Uruguay, livestock numbers have increased while land area has either declined or remained unchanged. These trends are primarily due to more intensive production systems. For example, in Bolivia, smallholder production in the mountains has decreased, while largeholder production has increased in the Amazonian region. In all other countries, both livestock population and land area have increased. The largest increase has been in Ecuador, Suriname and Costa Rica, where more forest land is being converted to grazing land.

5.2.2 Economic contribution of livestock

Annex Table 19 shows the total production in the region of meat from indigenous cattle, sheep, goats and pigs, as well as dairy milk. Brazil and Argentina together account for 57% of meat and 46% of milk. Meat and milk production has generally followed the same trends as livestock production.

The distribution of livestock in relation to human population is very uneven in the region (Annex Table 19). The highest per caput number of livestock are found in temperate South America (as much as 11.13 per caput in Uruguay). The lowest number is in the Caribbean sub-region. There has been a high increase in the demand for beef in the past decade. Between 1970-81, demand grew by an average annual growth rate exceeding 5% (Table 5.3). The highest increase was in Ecuador, matched by a corresponding increase in production. In Paraguay and Peru, demand grew while production declined, thus increasig dependence on imports. Argentina is the only country which has been self-sufficient in meat and milk products for many years. In 1986, Chile is reported to have joined the ranks of self-sufficient countries for meat. Venezuela and Bolivia have production rates greater than or equal to demand. In all other countries, the rate of increase in demand is still higher than that of production.

These rates of increase reflect the demand for meat (primarily beef) by urban populations, especially the higher income groups. Per caput consumption of pig meat has stagnated, while consumption of sheep and goat meat has declined to an almost insignificant level (FAO, 1986).

Table 5.3. Annual growth rates of demand and production of beef in the region (1970-1981)

Country/region	Annual growth rates (%) Demand	 Production
Bolivia	4.9	4.9
Brazil	6.1	1.5
Colombia	4.9	3.5
Dominican Republic	6.0	3.4
Ecuador	8.9	5.3
Mexico	4.4	3.3
Paraguay	4.4	-1.1
Peru	3.0	-1.3
Venezuela	4.2	5.4
Tropical America	5.3	2.2
Central America	4.0	3.3
Caribbean	3.2	2.0
Temperate Latin America	1.7	3.2

Source: CIAT, 1985.

The glut of meat over the past few years on the international market has adversely affected Argentina's exports. As a result more animals are being kept for longer periods on the range, thus increasing the pressure on grazing resources. The decrease in international prices has also discouraged investment in intensive forms of livestock management elsewhere in the region, thus sustaining the demand for imported meat.

However, the growing demand for meat is expected to stimulate the development of production and markets within the region. For most countries, this will problably take the form of intensification of production on existing lands, rather than on conversion of forest land.

6. WILDLAND AND WILDLIFE RESOURCES

Wildlands are those parts of national lands not under cultivation or intense human use. They may include any natural ecosystem from desert to wet forest. The Latin American and Caribbean region is notable for the diversity of its wildlands and wildlife. Over half the world's humid tropical forests occur in Amazonia (FAO/UNEP, 1981). An array of vertically-distributed habitats are found along the Pacific rim mountain ranges from Mexico to Chile. The Caribbean offers an opportunity of studying the biogeography of the propagation and extinction of island species, and has attracted naturalists since the times of von Humboldt and Darwin.

Until recently wildlands were seen primarily in terms of scientific interest or aesthetic value. A rapid degradation of these resources has occurred during the last two decades, principally as a result of land clearing for cattle pasture and agriculture. However, countries in the region, wildlands conservation organizations and international institutions are increasingly aware of the value of natural ecosystems to economic development (IUCN, 1982a). The role of protected areas in maintaining water quality and base flow quantity for potable water supply, energy generation and irrigation, are examples. Coastal ecosystems such as mangroves are essential to the reproduction and survival of most of the economically important fish and shellfish in the region.

Advances in biotechnology have shown the potential of these diverse tropical ecosystems. With rational management, many plants, plant products and animals can be harvested from natural ecosystems on a sustained basis. Income can be derived from ecosystems by providing minimal infrastructure for access. For example, the value to Ecuador of the Galapagos Islands in their natural state as a tourist attraction, far exceeds their economic value as goat farms, the next highest use.

Many tropical wildlands are fragile, due to soil characteristics, steep slopes and climate. Wildlife in such areas is often highly specialized and vulnerable to habitat disturbance. If wildlands are to be productive in the broadest sense, well-defined multi-purpose management objectives are needed.

6.1 EXTENT OF WILDLANDS

Throughout Latin America and the Caribbean there is a great expanse and variety of wildlands, though the rate of degradation and conversion to other uses is among the highest in the world in absolute terms.

The Caribbean. The Caribbean islands have two major types of landscape: low coral islands with a dry climate (the Bahamas, for example), and islands with metamorphic or volcanic mountains and a diversity of climatic regimes (such as Jamaica and Guadeloupe). In pre-Columbian times, these northern parts of the Neotropics were forested, with only the low islands and rainshadow areas on mountainous islands covered by dry climate vegetation. On the higher islands, the heavy forests have been greatly reduced.

Though forests are only part of a region's wildlands of savanna, mountain and desert, they are more vulnerable to conversion to other uses and are therefore most in need of protection. Wildlands on the Caribbean islands are found on approximately 23% of the land, ranging from 45% on Trinidad and Tobago to 2% on the Turks and Caicos. They are usually restricted to isolated mountain interiors and are crucial in maintaining water catchments. The wildlands of the Caribbean islands are the smallest, both in total area and as a percentage of island area. In Haiti, they have almost disappeared.

In sheltered bays, particularly on the leeward side of islands there are mangrove forests of varying extent. These areas have an important role in fisheries, as has been noted. Also, mangroves serve as feeding, reproduction and roosting areas for a variety of wildlife. Mangrove areas have been affected by expanding tourism, port development, pollution and upstream water diversion. Trinidad, however, has been successful in maintaining its Caroni Swamp Mangrove Park on the outskirts of its capital city, Port-of-Spain.

Mexico and Central America. The mainland includes Mexico, the five Central American countries and Panama. The area has in common a line of Pacific rim mountains stretching from northern Mexico into Panama. The landscape ranges from high coniferous forests and desert scrub in northern Mexico to extensive areas of dry and wet tropical forest to the south. In this area forests comprise the major part of the wildlands. One quarter of Mexico is still forested while other areas contain savanna and desert, all of which form Mexico's wildland heritage.

In Central America, approximately 36% of the land is forested, ranging from 55% in Panama to 7% in El Salvador, but deforestation is rapidly increasing. In a decade, wildlands have decreased by 26% in Costa Rica, 19% in El Salvador and 15% in Honduras. While these losses are perhaps irreversible, they often draw attention to the fact that remaining lands must be protected.

South America. Over half of South America is covered by wildlands. These contain over half the world's moist and wet tropical forests, a major desert coastal plain and a mountain area along the western flank of the Andes in Peru and Chile, paramo and puna vegetation associations of the high Andes, and extensive dry forests in the Caatinga, Cerrado and Chaco areas of Brazil and Argentina. All have rich wildlife resources.
In Brazil alone, some 5.5 million sq km (68% of the total area) are forested and in Suriname, 96%. Further south, in the subtropical parts of Argentina, Paraguay and Bolivia wildlands are in the low, dry forests of the Gran Chaco, the Pampas and Patagonia; Uruguay has 3% of its land forested. Loss of wildlands is generally reflected in loss of forests. In the 1970s, while Brazil lost only 3% of its forests, Colombia 12%, Ecuador 10% and Venezuela 7%, the combined loss of the four countries amounting to 285 000 sq km.

6.2 PROTECTED AREAS

One of the most effective means of conserving wildlands and wildlife is through official protection by national governments. This has long been recognized in parts of the region. Parks in Argentina, Chile and Mexico, for example, date from the mid-1930s. Table 6.1 lists the protected areas in the region.

Table 6.1 Protected areas in the region

Country	Total land area(a) (ha)	Lands protected(b) (ha)	% of total area	Protected since 1980(b) (ha)
Antigua/Barbuda	44 000	2 000	4.5	-
Argentina	273 669 000	2 594 351	0.9	28 000
Bahamas	1 007 000	122 540	12.0	-
Belize	2 280 000	5 318	0.2	5 318
Bolivia	108 439 000	4 707 690	4.3	180 000
Brazil	845 651 000	11 894 302	1.4	6 799 657
Chile	74 880 000	12 737 360	17.0	1 303 358
Colombia	103 870 000	3 958 750	3.8	-
Costa Rica	5 066 000	412 469	8.0	2 440
Cuba	11 086 000	24 305	0.2	-
Dominica	75 000	6 840	9.1	-
Dominican Rep.	4 833 000	219 800	4.5	-
Ecuador	27 684 000	2 627 365	9.5	146 280
Guatemala	10 843 000	59 600	0.5	-
Guyana	19 685 000	11 655	0.06	-
Haiti	2 756 000	5 000	0.2	5 000
Honduras	11 198 000	422 571	3.8	422 571
Mexico	192 304 000	938 448	0.5	48 334
Nicaragua	11 875 000	17 300	0.1	-
Panama	7 599 000	660 902	8.7	597 000
Suriname	16 147 000	582 400	3.6	-
Paraguay	39 730 000	1 120 538	2.8	40 000
Peru	128 000 000	2 407 642	1.9	477 721
St. Lucia	61 000	1 600	2.6	-
Trinidad/Tobago	513 000	16 523	3.2	-
Uruguay	17 362 000	28 778	0.2	-
Venezuela	88 205 000	7 388 912	8.4	-

Sources: (a) FAO, 1985c; (b) IUCN, 1985.

Variability among countries is high, with Chile having the largest proportion of its national territory under protection (17%) and the most extensive area in the region (12.7 million ha). Guyana, with 0.06% of its land protected has the lowest percentage in the region. Some countries (e.g. Barbados, El Salvador, French Guiana) have no designated parks. Since 1980, there have been substantial increases in the areas protected in a number of countries. Brazil's protected area increased by more than half, bringing it to 11.9 million ha, 1.4% of its land area; Belize, Honduras and Haiti established their first protected areas, and Panama extended its protected area by 90% to cover 8.7% of its land.

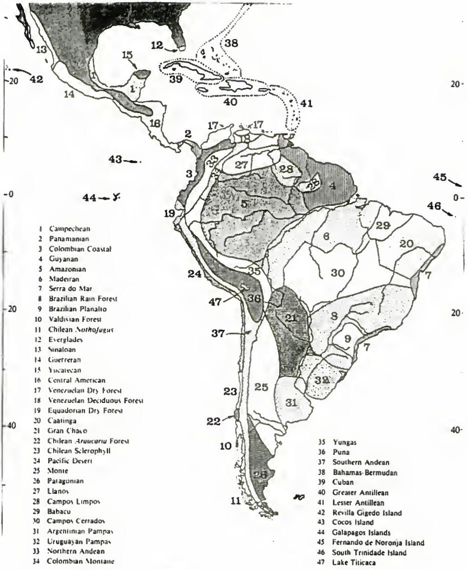
Biogeographical provinces of the world are divided into 8 realms, 193 provinces and 14 biomes. A biogeographical province is characterized by the biome which dominates, geographically, the area of that province A biome is a major regional ecological community of plants and animals extending over a large natural area. (Table 6.3). Almost all of the 47 Neotropical Provinces of the region are represented. (Fig. 2, Table 6.2). However, the number and areas vary widely. The Southern Andean Province has the most reserves (47), although the greatest area of protected land is in the Amazonian Province (almost 13 million hectares).

Table 6.2 Protected areas of Neotropical Provinces

Name of Province		No. of areas	Total area (ha)
1	Campechean	4	63 918
2	Panamanian	6	660 902
3	Colombian Coastal	6	1 019 000
4	Guyanan	21	2 152 078
5	Amazonian	14	12 733 681
6	Madeiran	2	448 150
7	Serro do Mar	8	196 468
8	Brazilian Rain Forest	16	447 233
9	Brazilian Planalto	2	15 839
10	Valdivian Forest	13	4 018 459
11	Chilean Nothofagus	7	4 367 307
12	Everglades	9	774 279
13	Sinaloan	5	462 994
14	Guerreran	5	66 873
15	Yucatecan	2	106 970
16	Central American	23	825 207
17	Venezuelan Dry Forest	26	1 125 794
18	Venezuelan Decidious Forest	11	546 930
19	Equadorian Dry Forest	3	181 300
20	Caatinga	3	236 100
21	Gran Chaco	6	1 175 000
22	Chilean Araucaria Forest	1	5 415
23	Chilean Sclerophyll	5	38 795
24	Pacific Desert	0	0
25	Monte	7	1 446 751
26	Patagonian	4	36 700
27	Llanos	3	1 207 000
28	Campos Limpos	3	3 192 000
29	Babacu	1	155 000
30	Campos Cerrados	11	2 457 403
31	Argentinian Pampas	0	0
32	Uruguayan Pampas	9	70 516
33	Northern Andean	9	913 288
34	Colombian Montane	8	1 397 050
35	Yungas	9	2 208 268
36	Puna	14	1 268 439
37	Southern Andean	47	6 450 237
38	Bahamas-Bermudan	4	122 540
39	Cuban	4	24 305
40	Greater Antillean	9	225 230
41	Lesser Antillean	6	87 875
42	Revilla Gigedo Island	0	0
43	Cocos Island	1	3 200
44	Galapagos Islands	1	691 200
45	Fernando de Noronja Island	1	36 249
46	South Trinidade Island	0	0
47	Lake Titicaca	0	0
	TOTAL	348	52 464 943

Source: IUCN, 1985.

Fig. 2. Biogeographical Provinces of the Neotropical Realm (Udvardy, 1975)



Source: IUCN, 1982a.

Table 6.3 Biomes of the Neotropical Realm

Type of Biome	No. of areas	Total area (ha)
Tropical humid forests	61	17 277 197
Subtropical/temperate rainforests/ woodlands	38	8 848 838
Tropical dry forests/woodlands	93	5 501 447
Temperate broadleaf forests	1	5 415
Evergreen sclerophyllous forests	5	38 795
Warm deserts/semi-deserts	7	1 446 751
Cold-winter deserts	4	36 700
Tropical grasslands/savannas	18	7 011 403
Temperate grasslands	9	70 516
Mixed mountain systems	86	11 037 282
Mixed island systems	26	1 190 599

Source: IUCN, 1985.

Designated parks beyond the settlement frontier generally remain intact until roads bring farmers, ranchers and lumbermen. However, parks bordering settlements may be subject to encroachment on their peripheries. Small parks, such as the Coroni in Trinidad and Tobago, Morocoy in Venezuela and the Galapagos in Ecuador, are all threatened in one way or another. The Coroni is downstream from an unprotected watershed and is contaminated by runoff from pesticides into the swamp. Its major attraction, the ibis, is affected by high tourist accessibility. The Morocoy is threatened by over-use from recreation activities, and the Galapagos from the numerous tourists and guided tours. Protection is most effective when areas are large enough to offset the impact of border encroachments, recreation, tourism and unprotected watersheds. In most cases they require the continuing support of outside institutions.

The Latin America and Caribbean Region is far behind Africa and Asia in using its wildlands for recreational purposes. Large reserves provide an opportunity to encourage tourism in appropriate numbers without disrupting the wild ecology, while at the same time contributing to the income of neighbouring rural communities and providing revenue for the wildland reserves.

6.3 STATUS OF WILDLIFE

A general set of principles regulating animal distribution and abundance apply to the region. These apply equally to forests isolated by development, large expanses of undisturbed forest, or small island habitats isolated from one another by the sea. Wildlife distribution is determined by the interplay of a variety of factors, both biotic and abiotic, including climate, habitat type and size, animal body size, mode of locomotion, reproductive strategy, feeding habits, commensalism (behaviour that is mutually favourable to two or more species) and social organization.

The structure of a particular ecosystem is the result of a dynamic interaction among past and present flora and fauna and the physical environment. The relationship between habitat size and species diversity has been formalized by MacArthur and Wilson (1967). Island fauna are often produced by random "innoculations" from mainland biota, with some species more able to migrate and invade an area than others. These fauna often show higher rates of extinction when disturbed than the more resilient mainland populations (Eisenberg, 1981). The fauna of the Caribbean and South America bear witness to the operation of these principles.

Due to isolation, the diversity of the Caribbean island fauna is lower than for habitats of similar area on the mainland. Few animals arrive and fewer still survive. The faunal diversity of Central America, on the other hand, is particularly high due to the patterns of mammalian migration into Central America of both neotropical and neoarctic species.

Extinction is a natural process, ultimately occurring with all species. Terborgh and Winter (1980) list the primary causes of extinction as consequences of population reduction produced by habitat fragmentation, negative population growth, species dependence on irregular food sources, alterations in food webs and commensual relationships between species, be they predator-prey or plant-pollinator. Natural processes of competition or subtle habitat change are doubtless factors of importance in extinction. However, they are generally masked by the pervasive effects of growing human populations. Demand for land for food and other uses, hunting and generation of wastes have resulted in rates of extinction far exceeding any known records.

The long-term survival potential and abundance of a wildlife species depend in large measure on the quality and size of its habitat. The clearest indicator of a species health is the rarity of individuals. Species abundance over time and habitat size all relate to extinction rates. The process by which a specific species becomes extinct takes an indeterminate period of time in an extensive habitat, but may occur rapidly if the entire range of species becomes fragmented due to human activity.

When a wildlife population has been severely reduced, the actual events leading to extinction of the last individuals may be random: a flood, storm, disease or simply reproductive isolation. These are all consequences of rarity; healthy populations are able to withstand such perturbations. These random losses of rare species may initiate chain reactions leading to further extinction, resulting in eventual ecological equilibrium with reduced faunal diversity.

Caribbean. The endemic fauna of the Caribbean islands contain species that have become extinct on the mainland. Species such as the solenodon (Solenodon cubanus and S. Paradoxus) are found only on Cuba, Haiti and the Dominican Republic. They are relict species, with archaic morphological characteristics (Eisenberg, 1975). Other relict species include the hutias, a family of primitive rodents found only in the Greater and Lesser Antilles. The avifauna, while more diverse than mammals, are often derivatives of mainland populations. Endemism is high with some species restricted to a few islands. These endemic populations are vulnerable to human activities such as hunting, habitat destruction and the introduction of competitive species. For example, endemic rodents, iguanas and ground-nesting birds are highly vulnerable to the introduced mongoose.

Central America. The fauna of Central America is highly diverse. Here the independently evolved fauna of the Northern and Southern Hemispheres mixed when the Central America land bridges formed during several geologic periods. The region's latitudinal and altitudinal gradients, floral complexity and climatic stability have resulted in large numbers of niches (distinct habitats), to which a highly diverse fauna has adapted. In Costa Rica, for example, there are 204 species of mammal, almost as many as in Australia. Costa Ricas's mammalian species/area ratio is among the highest on earth. (Eisenberg, 1981). There are 104 species of bat, 9 species of opossum and 7 of adentates (sloths, armadillos and anteaters).

Many of the wildlife species are highly specialized and interdependent with other species and are vulnerable to habitat loss and degradation caused by human activity. Central America has more bird species than the United States.

South America. Groups characteristic of the region include marsupials, primates, bats, edentates, and the only species of camel outside Asia. Generally, there is a north-south gradient of decreasing numbers of species typical of North America and increasing numbers typical of South America. For example, in Argentina there are 21 opossum species while in Costa Rica there are 9; there are 3 rat-like species (Neartic species) in Argentina while in Costa Rica there are 31. One third of the world's bird species are found in South America. Venezuela has 1 296 species.

The most threatened amphibians and reptiles in the region are the different caiman species (e.g. Caiman crocodilus yacare, C. crocodilus fuscus, Paleosuchus palpebrosus, P. trigonatus), crocodiles (especially Crocodylus acutus and C. moreletii), iguanas (Cyclura ricordii, C. cornuta cornuta) and turtles (Podocnemis unifilis, P. expansa, and Dermatemys mawii). The most threatened mammals are the jaguar (Panthera onca), ocelot (Felis pardalis), giant anteater (Myrmecophaga tridactyla), Caribbean manatee (Trichechus manatus), giant armadillo (Priodontes giganteus), bush dog (Speothos venaticus), Central American tapir (Tapirus bairidii), and giant otter (Pteronura brasiliensis) (IUCN, 1982b/c).

6.4 CONSTRAINTS ON WILDLIFE

Deforestation has caused fragmentation or loss of wildlife habitats throughout the region. In many cases, this occurs in stages: primary forest is logged for a few economically valuable trees, shifting cultivators follow the logging roads, felling and burning the remaining forest for their crops. In Latin America shifting cultivation plots are often converted to permanent pasture. Even without deforestation, alterations may reduce the utility of a habitat for a particular species.

Secondary forests often have fauna different from those of mature forests, and must await the long period of forest succession (40 to 100 years) before the original fauna returns. De Fonseca (1983) estimates that only 2-5% of the original Atlantic forest of Brazil remains, of which 80% is secondary growth. Habitat loss has been instrumental in the reduction of the woolly spider monkey (Brachyteles arachnoides). While habitat loss is extreme in several areas of Latin America, the commercialization of fauna has also resulted in the reduction of wildlife populations.

Sophisticated weapons and transport, and affluent markets have combined to bring increasing pressure on wildlife populations within decreasing habitats in Latin America. Hunting is carried out for three purposes: the skin trade, subsistence hunting, and the live animal trade.

Ojeda and Mares (1982) investigating the export of animal skins in Argentina (Table 6.4), found that, from 1972-1979, almost 22 million pelts of 20 species had been legally exported, trade accelerating in the last three years. The value of exports between 1976 and 1979 was approximately US $375 million. In 1979 alone, 11 million nutria (Myocastor coypus) pelts were exported, worth more than US $6 million. These figures do not include domestic consumption or illegal takes. It is difficult to imagine how a predator such as the gray fox (Dusicyon gymnocercus), could withstand an annual take of 750 000 individuals per year. These levels of mortality have resulted in the extirpation of many species in areas where they had been common.

Table 6.4 Mammalian pelts legally exported from Argentina

Species	Pelts exported (1972-79)	Value (1979) (US dollars)
Nutria (Myocastor coypus)	11 011 288	63 234 922
Gray Fox (Dusicyon gymnocercus)	5 789 011	40 877 042
Opposum (Didelphis marsupialis, D. albiventris)	1 541 717	65 905 760
Zorillo (Conepatus chinga, C. castaneus, C. humboldti, C. rex)	1 243 129	2 156 187
Vizcacha (Lagostomus maximus, Lagidum viscaccia, L. Wolffsolni	820 177	573 357
Geoffory's Cat (Felis geoffroyi)	481 333	3 557 671
Guanaco (Lama guanicoe)	443 655	3 557 671
Peccary (Tayussu tajacu, T. pecari)	312 115	328 052
Red Fox (Dusicyon culpaeus)	101 251	325 144
Capybara (Hydrochaerus hydrochaerus)	89 656	227 256
Pampas Cat (Felis colocolo)	82 195	875 033
Puma (Felis concolor)	2 571	15 520
Total:	21 918 098	122 684 692

Source: Ojeda & Mares, 1982.

Hunting practices are not restricted to Argentina. From 1946-1966 an estimated 138 000 ocelot and 12 700 jaguar skins were exported from Iquitos, Peru (Grimwood, 1968). Smith (1976) estimated that the annual take of jaguars from Amazonia was 7 000 and ocelots 40 000. Between 1965-1967 almost 2 million pelts of two peccary species were exported from Brazil, while in Peru, 2.3 million pelts of these same two species were exported during 1962-1972 (Smith, 1977).

Wildlife is an important source of protein for populations living at high altitudes, in wetlands and in very humid tropical forests, where domestic animals are scarce or unproductive. Subsistence hunting is a traditional practice of the rural population in Latin America which has not, until recently, adversely affected wildlife. Over the last two decades, however, colonization and the increase in human population in tropical forest areas, particularly in Amazonia, has resulted in an increase in subsistence hunting. Modern firearms are often used without legal or cultural controls.

Live animals are captured predominantly for the pet trade and laboratory purposes. Throughout the 1960s and early 1970s, this trade had considerable adverse effects on a variety of wildlife, particularly monkeys. From 1972-1973, for example, some 46 000 primates were exported from Iquitos, Peru (Table 6.5), primarily Saimiri. The trade in monkeys has been curtailed in the large North American market and the medical research industry is striving to reduce its use of imported primates.

Table 6.5 Export of monkeys from Iquitos, Peru (1972-73)

Genus	Total	Genus	Total
Saimiri	33 368	Saguinus	4 193
Lagothrix	3 587	Cebus	3 433
Aotus	1 007	Ateles	446
Callicebus	109	Pithecia	73
Alouatta	1		
	Total:	46 217	

Source: Smith, 1977.

Of the three types of hunting pressure on wildlife, the live animal trade is affected most by controls. Habitat loss and hunting have resulted in a number of wildlife species becoming endangered and threatened with extinction throughout Latin America (IUCN 1982 b,c).

6.5 WILDLIFE CONSERVATION AND MANAGEMENT

In some environments, the narrow range of domestic animals is only marginally productive. At high altitudes, in wetlands and in very humid tropical forest areas, the management or semi-domestication of native wildlife not only provides valuable protein but may also save some species from extinction.

Among the best known Latin American examples of effective conservation of wildlife is the vicuna in southern Peru, which was brought back from near extinction. In Costa Rica, scientists have improved local technology for raising in captivity the highly esteemed nocturnal rodent, tepescuintle or paca (Cuniculus paca). In El Salvador, the Ministry of Agriculture has worked with the people living around the Lake Jocotal Refuge to install nesting boxes for tree ducks. It was found that the ducks replace large numbers of eggs removed from the nests, allowing valuable food to be obtained while maintaining the wild duck population.

Wildlife conservation and management can contribute to rural development. Even strict protection of a wildland benefits rural areas by protecting the watershed and, indirectly, the settled areas. More immediate benefits to rural development can be derived from other types of wildlife management, especially sustained-yield harvesting of wildlands, wildlife farming and use of wildlands for recreation.

In Uruguay, a substantial local trade exists for the fur of the nutria (a water-dwelling small mammal) which is harvested on a sustained basis. A process for reproducing the green iguana in Panama is being worked out by the Smithsonian Tropical Research Institute which, if successful, will reduce pressure on this much sought after species.

Two reptiles that have been under severe pressure for their hide are alligators and crocodiles. Alligators are now raised in captivity and strategies for crocodile farming are being tested.

In the llanos of Venezuela, wild populations of capybaras (Hydrochoerus) are harvested on a sustained basis, the Ministry of Environment determining permissible harvests each year. In line with the strategy of integrated management, domestic livestock are allowed to graze alongside capybaras in some parts of Venezuela and Brazil because of the almost total lack of overlap in their diets.

The full potential for integrating wildlife with other forms of productive management has yet to be realized in the region. As the practice of raising wildlife in captivity and sustained harvesting from wildlands spreads, pressure on dwindling wild populations should decrease.

Wildlands and wildlife (i.e. functioning natural ecosystems), are intrinsically important for sustainable development. This is the basic theme of The World Conservation Strategy (IUCN, 1980), which outlines three living resource conservation objectives: maintenance of essential ecological processes and life support systems; preservation of genetic diversity; and sustainable utilization of species and ecosystems. IUCN, in collaboration with FAO and others, is currently revising its objectives for management of protected areas as well as its classification of types of protected land. This revision is in response to the need to clarify the status of those lands that are not totally protected and are available for partial use. The aim is to redefine the strategies and potentials for balancing conservation and production.

7. GENETIC RESOURCES

The humid tropics have a far greater genetic diversity than found at other latitudes. Two thirds of the approximately 3 million plant and animal species are found in the tropics (AID 1982). Of these, only some 500 000 have been catalogued and only a small fraction studied to determine their potential value to society. Genetic resources are being lost as a result of the increasing dependence of agriculture on a few high-yielding crop varieties and the destruction of potentially valuable wild plant and animal species.

7.1 PLANT GENETIC RESOURCES

Plant genetic resources are classified here by cultivated and wild species.

Cultivated plants include:

1. Primitive cultivars that have evolved through millennia of selection.
2. Obsolete cultivars, no longer cultivated because of the availability of improved varieties.
3. Advanced varieties, derived from plant breeding in recent decades.
4. Breeding lines, or material used in breeding programmes, such as parent lines, mutants, etc.

Wild plants include:

1. Wild progenitors and relatives of modern cultivated plants with potential for breeding or domestication.
2. Plants used in their unmanipulated state, such as forest trees, forage plants, fruits and nuts - sources of latex, medicines and chemicals.

7.1.1 Cultivated plant genetic resources

The Latin America and Caribbean Region has several centres of origin of cultivated plants, including Mexico, the Andes and Amazonia. This is due in part to the ecological diversity of the region, the many associated niches for different crop varieties and to the plant breeding efforts of the indigenous peoples (Sauer, 1952). In addition to the few dozen economically important crops there are thousands of potential value. Among the best known domesticated species from the American tropics are corn (maize), capsicum peppers, cocoa, cucurbits, cotton, beans, various types of potato, cassava (yuca), peanuts, sweet potatoes and tomatoes. Each is representated by a number of locally important cultivated varieties and wild relatives.

Agricultural systems have become more intensive and tend to focus on a few food and industrial crops, which are manipulated genetically to provide a few genotypes particularly responsive to high levels of fertilizer and water. Genetic diversity has been sacrificed for production efficiency. In Latin America, hundreds of corn and potato varieties were created through selection over thousands of years, in response to local conditions and tastes. These varieties are now being replaced by a few hybrid corn lines largely for the animal feed market, and a few high-yielding potato varieties for urban consumers.

Other genetically-diverse crop species are selectively bred for high yield under capital and energy-intensive agriculture. Varieties adapted to marginal soil and rainfall conditions, resistant to local pests and suited to local tastes, are of little interest to commercial farmers on the best land, with irrigation and chemical formulations to correct any soil deficiency and protect against most pests.

The crop genetic resource base is being steadily eroded as many of the traditional varieties are abandoned when competition causes the small farmer to stop cultivating a crop, or shift to a high-yielding variety. Many thousands of "dooryard" gardens have long been a focus of plant selection and maintenance of crop diversity. As small farmers shift to monocultures or migrate to cities, genetic diversity is lost. Preference for European food (wheat, cabbage, lettuce, apples) and prejudice against "Indian" food limits the market and thus the incentive to cultivate and improve traditional crops.

Virtually all cultivated plants have a number of wild relatives. The conversion of natural ecosystems to cropland and pasture results in the loss of many of these potentially useful plants. Given the extent of land degradation in Mexico, it was indeed fortunate that a perennial corn relative was still around to be discovered. As indigenous peoples become acculturated or translocated, both their diverse cultivated gene pool and their knowledge of useful wild plants are generally lost.

In 1974, the International Board for Plant Genetic Resources (IBPGR) was established in response to continuing loss of genetic resources. The basic function of IBPGR, an autonomous international, scientific organization, is to promote an international network of genetic resource centres to further the collection, conservation, documentation, evaluation and use of plant germplasm. Germplasm in this context includes seed and vegetative material for direct planting as well as tissue culture and other biotechnological applications.

Germplasm of crops and their wild relatives indigenous to the region has been collected. In the Andean highlands collections were made of quinoa, maize, lupine and some indigenous tuberous crops. In other parts of Latin America cotton, maize, groundnut and Phaseolus beans were collected. Conservation of the collected material involved regeneration, evaluation, multiplication, long-term storage, and distribution of accessions to interested plant breeders (FAO, 1983d).

IBPGR has set up a global network of crop genetic resource centres. The International Potate Centre in Lima (Peru), holds 13,000 clonal accessions from throughout Latin America. The data is computarized so there is ready access, and use of the germplasm for breeding and evaluation research is facilitated (Huaman, 1981).

Some genetic resource centres have been criticized in the past for inadequate storage facilities that increased the rate of deterioration of material, insufficient trained personnel, and lack of access to stored genetic material by plant breeders. There was no cooperative agreement guaranteeing the continuation of activities by gene banks. It was not feasible for all countries to invest in national gene banks due to financial and manpower constraints. These and other reasons led to a proposal for an international gene bank for plant genetic research (FAO 1983d).

The activities of IBPGR and other institutions are an important contribution to maintenance of crop genetic resources. However, many of the collections still represent only a small part of the genetic diversity being lost. It is physically and economically impossible to carry out wholesale collection and storage; a more extensive survey is needed to determine which genetic resources should be collected. Present collections contain only cultivars and wild relatives of crops of economic importance. While this may be a prudent course of action for countries with limited financial resources, there should, nontheless, be a long-term strategy for extending knowledge of available wild species, and analysing which might be of economic importance in the forseeable future.

High priority should be given to native leafy vegetables. In the tropics of the region hundreds of species of wild and cultivated plants are used. Their importance is often underestimated because of limited commercialization and failure to realize their nutritional value (FAO, 1981e). In Peru, for example, low prestige attached to leafy crops has led to their widespread abandonment in favour of European crops such as spinach, cauliflower and celery. Among these native plants are a dozen or more *Amaranthus* species, *Chenopodium ambrosioides*, *Portulaca oleracea*, *Tropaeolum majus*, *Nasturtium offinali*, *Rumex crispus* and *Sonchus oleraceus*. Many grow as weeds on the borders of fields and along roadsides. The protein, calcium and iron content of these hardy native vegetables average two to three times that of European crops requiring heavy fertilization and pesticide application (Hurtado, 1977).

The physical infrastructure, technology and trained personnel needed to maintain modern gene banks is very costly. Therefore, *in situ* conservation should be encouraged as a complement to gene banks. Conservation of cultivated plant diversity can be encouraged and sustained by:

1. giving the small-scale farmer and the rural landless population secure tenure to land in diverse ecological settings, thus encouraging polycultural gardens and long-term stability on the land;

2. ensuring that indigenous groups have a secure land base within their historic territory;

3. promoting cultural awareness and pride in national and regional foods, particularly when those foods have a far higher nutritional value than exotics (Hurtado, 1977);

4. creating research, extension and marketing systems that serve small farmers growing a diversity of crops, as well as large-scale monocultural farmers and ranchers;

5. subsidizing small farmers who maintain and reproduce desired crop varieties.

7.1.2 Wild plant genetic resources

The conservation of wild progenitors requires the preservation of intact ecosystems. It is impossible to determine the number of plants to be preserved when many have as yet to be identified. It is prudent to preserve areas representative of the major ecological Life Zones within a country or region. Such biotic reserves can be used for purposes that do not conflict with the primary one of conserving biotic diversity. The loss of natural ecosystems through deforestation is primarily the result of shifting agriculture and extensive cattle ranching. The following are ways of reducing pressure on natural ecosystems.

1. Modifying policies that require land to be deforested in order to be titled.
2. Developing agriculture where supporting infrastructure, services and markets already exist, rather than penetrating into the wet tropics.
3. Carrying out land capabilities studies for agricultural development schemes. Areas designated for watershed protection can also serve as genetic diversity reserves.
4. Legally establishing a series of multiple-use reserves in representative ecosystems. Since the benefits of genetic diversity accrue to all people of the world, those countries most able to finance conservation efforts should do so.

Taxonomic identification and preliminary screening of the vast array of species in the remaining natural areas of the region is a formidable challenge. Unlike many areas of biology requiring costly equipment, plant exploration, collection and classification require little investment (Wilson, 1984).

A major beneficiary of plant classification is medicine. Past exploration of medicinal plants concentrated on superior sources of phytochemicals and new drugs, rather than on collection of genetically diverse material (FAO 1981e). The diversity of plants with potential medical properties is so great that collections for gene bank maintenance can be attempted only when their use has been discovered. In the interim, natural ecosystems will remain the cheapest banks for maintaining genetic material with potential.

7.2 FOREST GENETIC RESOURCES

Loss of forest genetic resources has been attributed to ecosystem destruction, and intensive breeding and selection for uniform high performance strains (Palmberg 1981a).

Much of the natural pine forests in the Caribbean and Central America have been destroyed during the last twenty to thirty years. There is great diversity within and between pine populations, Pinus caribaea and P. oocarpa being the most important species. The genetic variability of these species and others in the region makes it important to intensify conservation efforts to preserve these unique genetic resources.

The diversity of forest genetic resources is being narrowed as a result of widespread clearing of tropical forests and their replacement by monocultural plantations with a few exotic species. Dominant among the exotics are eucalypts and pines (outside their native range). The number of plantations of native trees in the region is negligible. Genetic improvements for greater uniformity and higher yield increases the susceptibility of plantations to disease and pest attacks, and decreases genetic flexibility for future breeding of plants to meet market demand or to achieve disease resistance. Exotics of known and desirable characteristics are encouraged to the detriment of research in the use of indigenous species (FAO 1977).

Action is required to safeguard the genetic diversity of species and provenance through conservation (Palmberg, 1981a). Conservation embraces utilization and preservation. The wide variations and successional status of ecosystems, the different reproductive habits of species, and other factors, prevent the adoption of a single conservation strategy. There is also an array of species other than timber trees, (such as shrubs, grasses and forbs) which render valuable products and stability to the ecosystem, and which must be included in any conservation measures used (FAO/UNEP, 1980a).

The Instituto Nacional de Investigacion Forestales (INIF) in Mexico has implemented forest genetic resource programmes in Central and South America. It has established several regional centres and six research stations for species with timber, fodder, food and medicinal uses, such as Pinus pseudostrobus, P. oocarpa, P. patula, Eucalyptus camaldulensis, E. citriodora and Atriplex spp. There are forty three indigenous pine species in Mexico and over the past decade seed from some of these have been distributed for international provenance trials.

The principal threat to arid and semi-arid zone tree species is the destruction of natural ecosystems resulting from overgrazing and fuelwood cutting (Palmberg, 1981a). INIF gives high priority to evaluating species and provenances of multi-purpose tree species which can bring direct benefits to rural communities. Included are genera such as Prosopis, Acacia, Atriplex and some exotics such as Eucalyptus. These plants can provide animal fodder, timber, energy (fuelwood), food, raw materials for medicines, and help stabilize the soil. To this list may be added Opuntia cactus and Agave, sources of food, feed and erosion control, and Simmondsis chinensis, Euphorbia antisyphilitica, and Parthenium argentatum, sources of high-quality oil and wax.

Some genera (e.g. Prosopis and Acacia) are nitrogen fixers (i.e. they can obtain nitrogen from the air), and can be used to enhance soil fertility (FAO, 1980). Unfortunately, few arid or semi-arid zone tropical tree species have been sufficiently studied, either genecologically or technically, to provide a solid base for their efficient utilization and conservation (Palmberg, 1981b). This problem is even more acute in the humid tropics with its immense diversity of poorly-known species.

The first stage in introducing trees (from natural forests of the region or plantations outside) is to conduct species trials to determine which are best adapted to the environment. Continuity is essential to ensure that trees planted under one administration will not be abandoned by another. At the national level, facilities are lacking to publish results of trials and they are not communicated via international journals to neighbouring countries where similar trials may be underway.

FAO has been instrumental in establishing international provenance trials for fourteen tropical and six sub-tropical species, and has aided in the establishment of national seed centres in Chile, Colombia, Guatemala, Honduras, Costa Rica and Peru; 160 species have been placed on a "Priority 1" rating list (FAO 1981e).

Provenance trials determine the genetic variation within a species particularly as it affects such economically important variables as growth rate and form, resistance to disease and pest attack, and wood characteristics. For example, high variability in growth form and rate are limiting factors in establishing pine plantations in countries outside their range of natural occurrence. National forestry institutions in a few countries of the region, notably Mexico, Brazil and Argentina, conduct provenance trials. Most earlier trials focused on pines and eucalypts, not on the hundreds of promising native hardwoods.

Species may be conserved in situ or ex situ. The former involves protecting the species in its natural habitat. Disadvantages of this type of conservation are inability to manipulate the species and the difficulties inherent in maintaining a natural area in the face of pressure for other uses. However, the genetic resources found in natural forests, even those in national parks and reserves, are vulnerable to loss because of lack of recognition of their value and lack of enforcement of existing protective legislation. Pilot surveys are needed to determine the diversity within and among species in protected areas (FAO/UNEP,1980a).

Categories of in situ protected area. Four of IUCN's 10 categories of protected area (IUCN 1983) are relevant in the context of forest genetic conservation.

1. Strict nature reserves, where the objective is to protect species and maintain natural processes in an undisturbed state.

2. Managed nature reserves, to protect nationally significant species which require human manipulation for their perpetuation.

3. National parks, to protect areas of national or international significance, and perpetuate representative samples of biotic communities, genetic resources and species in danger of extinction. Recreation activities are allowed on a controlled basis.

4. Managed resource areas where conservation of nature is primarily oriented to support economic activities. Planning programmes to ensure the area is managed on a sustained yield basis is a prerequisite.

Ex situ conservation implies protection of material (living trees or seeds) outside its natural habitat. For trees, this involves finding an ecologically suitable alternative site which can be maintained for several decades. Because of the interest in plantation forestry rather than in native forest management, ex situ conservation is more favoured in the region.

7.3 ANIMAL GENETIC RESOURCES

Before the European contact at the end of the fifteenth century, Latin America and the Caribbean were poor in domestic animals. Only the guinea pig, dog, llama, alpaca, muscovy duck, turkey and black chicken (considered of Asian origin) are known to have been domesticated (Sauer, 1952). None of these was raised throughout the region, the dog and turkey being most widely distributed. With the Spanish and Portuguese came the horse, pig, cow, goat, sheep, donkey, rabbit, chicken and duck. These animals became acclimatized to the higher and drier Life Zones and eventually to the more humid ones. Over time the original stock, mixed occasionally with later importations, evolved into recognized breeds well adapted to local conditions. As the animals of European origin spread, they supplanted many of the native domesticated ones as sources of food, wool and transport.

The Iberians wrought a massive change in diet, land use and social structure as their strong cultural predilection for cattle ranching became dominant. Previously, the people of the region had been predominantly agriculturists with a low animal protein intake, usually a result of hunting not animal husbandry.

During this century, and particularly since World War II, a major effort has been made to replace or upgrade native (Iberian) stock with more productive breeds from the United States and Europe. The focus has been on cattle, with relatively little attention given to swine, poultry and sheep. The Zebu or Brahma cattle, originally from South Asia, were an early introduction, rapidly replacing the locally-adapted Criollo breeds in the hot, humid tropics, because of their resistance to ticks and more rapid growth. A large increase in productivity was attributable to hybrid vigour imported by cross breeding with the adapted Criollo cattle (Mason, 1981). It was also found that Criollo breeds could impart the same hybrid vigour to introduced temperate climate beef and dairy cattle (De Alba et al, 1984).

Improvements in nutrition and health care have also played an important role in the adaptation of temperate breeds. The adapted Criollo breeds are threatened by a narrowing genetic base as their numbers decrease. Criollo dairy cows are estimated to be 8 000 head (Wilkins et al, 1984), with a continuing decrease in true Criollo throughout the region.

Camelids (llama and alpaca) have decreased in numbers in the Andean countries, particularly in Peru and Bolivia. This, together with the near extinction of the wild vicuna and guanaco populations, has reduced the efficiency of grazing land above 4 200 metres, which is unsuitable for cattle and sheep. The wild species are now on the increase since Peru, Chile, Bolivia and Argentina signed a treaty for their protection.

Genetic diversity of native and adapted animals in the region that should be conserved include:

1. Criolo cattle. Populations must be increased and a careful breeding plan adopted to maintain the hybrid vigour in the cross breeds while not decreasing the existing genetic variation within the population (Wilkins, 1984).

2. High altitude species, such as domesticated camelidae, llama and alpaca. These animals make efficient use of the sparse grazing lands of the Andean altiplano, and their wool, meat and hide support subsistence agriculture (Novoa, 1981).

3. Indigenous and adapted sheep and goats, for example, the tropical hair sheep (of West African origin) and the wooled Criollo are important sources of adapted genotypes (Mason, 1981).

4. Other adapted domesticates including chinchillas, guinea pig, pigs and poultry.

The capacity for evaluation and conservation of animal genetic resources exists in many countries of Central and Latin America. What is needed, according to Muller (1980), is increased coordination and financial resources. It is important to set up national data banks for animal genetic resources based on existing institutions.

There are several ways to reverse the loss of genetic diversity, for example through the use of live breeding populations, frozen semen from sheep and cattle, or frozen embryos. Frozen semen and embryos can include small samples from diverse stocks, stocks with special traits or locally-adapted breeds (Smith, 1984b). It is important to store a wide selection of the chosen stock, not only the best specimens.

Maintenance of genetic flexibility for the future is particularly important in developing countries which need to preserve and improve their indigenous breeds.

8. INTEGRATED AREA DEVELOPMENT

Integrated area development is widely practised in Latin America and the Caribbean, encouraged and supported by the Organization of American States (OAS), the Inter-American Development Bank (BID) and the US Agency for International Development (USAID).

An "area" here is considered to be a coherent sub-national unit chosen for the purpose of development. It may be defined by physical or biological features (e.g. the treeless plain of the llanos of Venezuela and Colombia, the Amazonian floodplain vegetation and soil known as the varzea, the watershed of a river system); or by historical or modern socio-cultural parameters (e.g the Otavalo region in Ecuador); or it may be a political unit (eg. a municipality or province). An area for integrated development may vary in size from the six million sq km Amazon basin shared by six countries to an urban area of 100 sq km. Most important is that the definition be understood by all participants in the planning process.

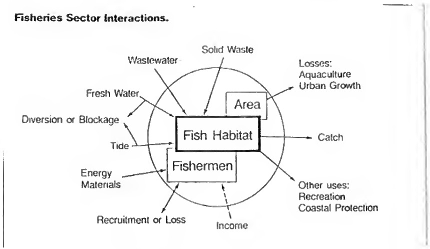
Development is the rational managment of the environment (the inter-connected terrestrial and aquatic ecosystems) to provide goods and services on a sustained basis for human well-being. Goods are the natural resources harvested and transformed for use. Services are those dynamic processes in the environment which directly or indirectly benefit society, be they economic, social, cultural or scientific.

Integrated area development is a complex process of balancing sectoral interests with broader, long-term interests. Being multisectoral in scope, a coordinated interdisciplinary effort is required, i.e. a team approach with communication among the sectors involved. As it is assumed that the process will lead to improvement in human conditions through the sustainable use of natural resources, there must be a just distribution of benefits. All projects have targets or beneficiary groups. There may also be groups whose interests are prejudiced by the project. Integrated development should minimize conflict and compensate those negatively affected.

At the planning stage, it is necessary to discern the most significant among the many development activities envisioned. In the case of reservoirs, for example, it is not necessary to make an exhaustive study of erosion for the whole watershed. It is sufficient to identify the areas where sediment actually enters major reservoir tributaries, and what proportion entering the reservoir is excavated from the stream bed. This will show priority areas and determine the proportion of erosion that is uncontrollable. If this proportion is high, the viability of building a dam in the watershed is debatable.

Frequently, planners do not perceive that their activities may adversely affect other sectors. An inter-disciplinary analysis of a country or region is a means of identifying interaction with other sectors. Fig. 3 shows some of the interactions of one sector (fisheries) with others within a local regional system. The output from one component (e.g. water, forest products or wastes) may become the input, desirable or not, in another component or system.

Fig. 3. An example of intersectoral interaction



Source: Dickinson, 1984.

Integrated area development enables a clearer picture to be obtained of how a region or country functions as a system and its potential for development. It allows individuals of diverse disciplines and sectors to appreciate how their knowledge fits into the overall scheme. The identification, quantification and evaluation of interactions permit management options to be defined and potentials assessed (Dickinson, 1984).

8.1 PROJECT FORMULATION

A scheme for the design of development strategies and the formulation of investment projects has been established by OAS, based on twenty years' experience (OAS, 1984). This integrated development approach provides a useful framework for development assistance institutions when designing projects.

Integrated planning is a flexible process, not a formula. Prior to committing resources, it is important that a preliminary (pre-feasibility) mission define the area to be developed, the intended scope of activities, the expenditure envisioned and the agencies to be involved. This is followed by the diagnostic and project formulation phases.

The diagnosis phase is a systems approach to identify relevant data, and organize interdisciplinary team activities. An inventory is made of the basic components of an area - natural ecosystems and their associated soil, water and living elements; managed systems including agriculture, aquaculture and sylviculture; urban-industrial centres; transport infrastructures; legal and institutional aspects. Actual and potential land use is compared to identify the sectoral activities associated with each component. The capacity of supporting institutions to provide education, research, extension, credit, materials and marketing assistance is assessed. Inputs and outputs are identified within the boundaries defined for the area. These include rainfall and river flow, goods and services used in the area and outputs to other areas, such as river outflow, products and contaminants. (Inter-American Development Bank, 1981).

With this basic information, development opportunities and constraints can be identified, alternatives formulated and projects designed within the context of national development strategies and priorities. Environmental scientists have an important role to play with sectoral experts in analysing specific issues and identifying intersectoral conflicts within and beyond the area. In this context the environment is not considered a sector but rather the regional system within which all sectoral activities take place.

An evaluation is made of the social, cultural and economic (as distinguished from financial) situation in the area, as affected by existing or proposed sectoral activities. It is important to evaluate the land tenure situation which affects access to land and the effectiveness of institutions in providing goods and services, such as fertilizers, and extension and marketing assistance. Potential target groups for sectoral projects are identified as well as those likely to be adversely affected by the proposed activities. Attention is given to indigeneous people who may lack effective political representation.

As projects are formulated at the pre-feasibility level, it is important that the intersectoral systems perspective evolved during the diagnosis phase be maintained (Annex Table 21).

The feasibility of a proposed project should be evaluated at the following four levels, with emphasis as appropriate:

1. Extra-regional scale. Larger than the planning area and may include urban or international sources of goods and services or markets. Resource availabilty should be assessed at the appropriate level when export of a product is involved, or use of technical assistance, materials, capital investment or water supplies from outside the area.

2. Regional scale. The area may be a province or a region defined by natural features, such as a sea coast or intermontane valley. A comparison is made of several sites with similar soil resources to find the most suitable with respect to: transportation infrastructure, support services and water supply; the site where the proposed activity will pose the least threat to other sectoral activities; and where the natural ecosystems can provide goods and services.

3. Watersheds are closely associated with land forms, soils, vegetation and land capability. Areas can be defined according to river basin or watershed. River basins are sub-divided into convenient watershed units for projects in soil and water conservation, agriculture, forestry and fisheries. The OAS Pilcomayo Project, the Amazon Project, and the Guayas in Ecuador are examples of this approach.

4. Farm systems. Within a watershed are individual management units or farms varying in size according to land capability, population pressure and tenure structure. Only in the last decade has agricultural research and development assistance been oriented to the family farm as a system, reinforced by the recognition of the important role of women in agriculture. Farms are ecological and economic systems operated by families within a specific cultural context. The concept can be extended to family-scale fishery, aquaculture, livestock and forest management activities.

8.2 THE WATERSHED IN INTEGRATED AREA DEVELOPMENT

A watershed is the land area drained by a stream and its tributaries. Precipitation within a watershed returns to the atmosphere through evapotranspiration, is stored for varying periods as groundwater in lakes or reservoirs, or runs off the land to form a river. The runoff from an undisturbed watershed has a characteristic hydroperiod or discharge rate (usually measured in cubic metres per second), reflecting the type and amount of precipitation, soil characteristics, vegetation and topography. Discharge rate is associated with water quality - dissolved minerals, organic matter content and type, and sediment.

Mountain watersheds are of particular concern because of their physical and cultural diversity, fragility, and degradation due to human pressure. Mismanagement can jeopardize agriculture, fisheries, power generation, and navigation downstream. Changes in the hydroperiod due to human activities in one part of a water shed affect downstream activities. For example, road construction through an upper watershed encourages spontaneous settlement; runoff increases as a result of land clearing which is followed by erosion; the rapid increase in tributary stream flow results in more erosion with three major impacts downstream. First, the stream bed is raised by sedimentation, destroying fish habitats and causing increased flooding during high-flow periods. Second, more rapid runoff means less water stored in the soil for slow release with resultant lower dry-season flow affecting fish and all water users downstream. Third, reservoirs for power generation, irrigation or potable water supply are adversely affected by sedimentation, wet-season overfilling and dry-season scarcity.

Impoundments themselves change the hydroperiod, reducing stream flow, affecting downstream freshwater and estuarine fisheries dependent on fluctuating water levels and reduced salinity at certain times of the year. Saltwater intrusion increases and floodplain soils are not renewed.

A study of the Suriname River watershed found that the establishment of a constant flow in the river below the Brokopondo Dam virtually eliminated the freshwater fish that depended on seasonally-flooded forests for feeding. In the OAS Guanare-Masparro study three predictable but unanticipated impacts of flow regularization and flood control are noted:

1. Floodplain basins (esteros), subject to seasonal inundation, serve as areas of wet-season feeding and reproduction for various economically important fish species. Flood control destroys this habitat.

2. Grasses spring up in abundance in the basins as water recedes with the onset of the llanos dry season. Cattle under traditional management depend on this supply of fresh grass and water to carry them through the dry season. This too is lost with flood control and drainage.

3. Several fish species ascend the rivers with the onset of the dry season to find pools of permanent water in Andean piedmont. Their migration is blocked by dam construction (Dickinson, 1982).

While few sectoral projects encompass an entire watershed, most interactions between a project, other sectors and the supporting resource base occur at the watershed level. Integrated area planning at this level can identify potential problems early in project formulation and, if necessary, suggest an alternative location, scale, design or operation to mitigate conflict with other sectors.

The preliminary mission defines the development goals for the area. The first step of the diagnosis phase is to translate regional goals into specific watershed objectives in keeping with the land and water use capacity in the area. In OAS studies of the Darien of Panama, the Dominican Republic, the Santiago-Mira area of Ecuador, and subsequent studies in Peru and elsewhere, Life Zone mapping was combined with geomorphic analysis, and a preliminary soil survey was made to arrive at a Life Zone association classification of land capability. When capability maps are compared with actual land use, conflicts are easily identifiable. It was noted in the Dominican Republic that using maps of differing scales was difficult and time consuming. Today, relatively inexpensive geographic information systems are available which allow digitized resource maps at varying scales to be compared.

At the core of watershed management is the rational use of soil and water resources, which benefits fisheries, irrigated agriculture, energy generation and urban areas, as well as wildlife. Terracing and contour ploughing result in medium term on-farm benefits along with the off-site water conservation benefits. Restriction or prohibition of agriculture or forest use to achieve water management goals represents opportunity costs borne by the agricultural and foresty sectors. Rehabilitation of already degraded areas, particularly dams, is initially a costly undertaking, with a slow accumulation of benefits either on-site or downstream.

The number of watershed management projects in South America has declined in the past decade, due to institutional, fnancial and technical problems. It is difficult to obtain financial assistance because watershed management projects provide long-term rather than immediate economic returns. In addition, they require a coordinated effort among several government ministries and the active participation of local people, both of whom are often left out in the design and implementation stages of watershed management programmes or projects.

In recent years, Venezuela, Columbia and the Dominican Republic have implemented watershed management projects integrating all types of land use (agriculture, forestry, livestock, etc.). The possible impact of upstream activities on downstream users is taken into account, together with social and cultural aspects. In Colombia, the revenue from a tax on the sale of hydroelectric power in urban areas is re-invested in the watershed area of a dam. Half of the revenue is used for rural electrification, and the other half for watershed management activities.

Other watershed management projects in the region concentrate on upland soil and forest conservation activities, but have difficulty in establishing integrated structures because of institutional constraints. Watershed management projects sometimes confuse reforestation with revegetation on degraded, steeply sloping sites. Erosion can be reduced and water infiltration increased by the inexpensive expedient of excluding grazing animals, and using fire to promote revegetation. To engage in expensive reforestation with timber trees can be uneconomical and assessments generally show that such sites should be left in undisturbed natural forest. When trees inappropriate for soil conservation (e.g. eucalyptus) are planted, the investment makes even less sense.

There are far more watersheds in need of conservation in the region than can be funded by governments and development assistance agencies. Priorities must be established for watersheds where the maximum benefit can be derived from modest investment, those which would benefit from conservation, and those beyond economic recovery. In the first category are watersheds whose upper parts are relatively undisturbed, and whose lower parts have potential for hydro energy, agriculture or fisheries. In the second are watersheds currently over-exploited. In these areas, conservation practices must be built into local farming systems.

Coordination among countries with similar watershed problems is important to avoid duplication and to exchange information, expertise and research. An excellent way to achieve this is through a network approach. FAO has established the Amazon Agrarian Research Network (RDINNA), which focuses on soil management, pasture improvement and forestry. FAO also sponsors a watershed management network for exchange of information and expertise within the region. Through this network the National Electrification Institute of Ecuador (INECEL) was able to call upon expertise from Chile and Colombia to explore strategies for management of the watersheds of hydroelectric projects.

There are two other networks in the region: the Caribbean Network on Upper Watershed Management (for Caribbean countries) and the Regional Cooperation Network in Watershed Management (covering Latin America). Their mandate is to strengthen watershed management activities through workshops, training courses and meetings; to facilitate the exchange of information between countries and to coordinate activities which span several countries, such as the Rio Parana watershed in Argentina, Brazil, Uruguay, Paraguay and Bolivia.

8.3. COASTAL ZONES

The coastal zone represents a special case in watershed management. The coast is the focus of a variety of often conflicting sectoral activities: fisheries, aquaculture, intensive agriculture, wildlife management, recreation and tourism, urban-industrial and port development, and piedmont dams for energy and other uses. The smaller islands of the Caribbean are essentially a closed circle of coastal zone with limited alternatives to disperse conflicting activities.

Coastal marshes, mangroves and coral reefs have in common their productive fisheries and role in coastal stabilization. Marshes and mangroves are open systems dependent for productivity on both upstream runoff and tidal exchange. Coral reefs are dependent on wave action and tidal exchange with the open sea, and even a small amount of nutrients and sediment from the land can be detrimental. As open systems, all three are vulnerable to contamination and to activities such as road building. In Panama, coral mortality is linked with the intensive use of pesticides in the coastal plain. The Baranquilla-Santa Marta coastal highway in Colombia, built without adequate provision for tidal exchange or freshwater flow to the estuary, was responsible for the loss of mangroves and a decline in fisheries on both side of the highway. Such problems are predictable and can be mitigated through an interdisciplinary area planning approach.

8.4 FARM SYSTEMS

Integrated area development planning applied at the regional and watershed levels finds its ultimate expression at the farm level. In the final analysis, most natural resource management decisions are made by individuals. Deforestation, erosion, overgrazing, burning and over-exploitation of floral and faunal resources are the result of individual activities. While people may be influenced to a limited degree by education, media campaigns, credit facilities and subsidies, a more effective mechanism to reach them must be found. A farm-system approach within an integrated area development framework can provide that mechanism.

A farming system has been defined as a stable arrangement of farming enterprises, operated by a household according to well-defined practices, in response to the physical, biological and socio-economic environment and in accordance with the household's goals, preferences and resources. These factors combine to influence output and production methods. (FAO, 1984e, Shaner, 1982).

The size depends on environmental conditions and population pressure in a particular area, but is usually a small-scale farming operation. In tropical America, a farmer may plant annual row crops; practise horticulture, small or large-scale animal husbandry and sylviculture; hunt, fish and process goods for the market. Such a farmer is not served by crop and cattle programmes designed to meet the needs of large entreprises.

The farm system approach has promise as a means of improving the economic lot of a large segment of the region's society. The organization and management of individual farm units and the structure of government support is important. The farm system approach is a natural outgrowth and complements the integrated area development perspective.

8.5 EXPERIENCE IN THE REGION

Integrated area development experience in Latin America and the Caribbean shows that exhaustive resource inventories and large scale detailed mapping for entire regions are not mandatory for effective planning. In the 1960s, a massive inventory approach in the Dominican Republic delayed the planning process with resultant loss of momentum, as sectoral projects moved ahead under their own economic impetus. There is a tendency for a single sectoral element of a complex, regional programme to become the dominant, if not the only, activity executed.

Venezuela, Colombia and Brazil are foremost in the region in autonomous, well-funded regional development corporations. Peru has embarked on a similar process of decentralization. Such entities have more potential to carry out planning recommendations than do national planning institutes, as they combine planning and execution under one administrative structure.

The Palcazu Project in eastern Peru, designed as an integrated area development project following a government decision to build a road through the Palcazu Valley, is translating plans into action. Amuesta Indian lands have been titled, and national parks and forest lands defined, in concept if not yet legally. Experiments in tropical forest succession management, agroforestry and tropical fruits are underway. The main constraint is imposed by the Valley itself with its 6,000 mm per year rainfall, poor soils and difficult topography, which makes it difficult to get technical expertise into the field, where on-farm projects are executed.

Land capability studies, settlement schemes, watershed management plans and social programmes are complex and require much more coordination than do infrastructural elements such as dams. The neglect of these supporting elements stems from a lack of conviction on the part of national agencies and financing institutions of their political and developmental value.

ANNEX TABLES

Annex Table 1. Population data

Country	1985 Population (000)	Rate of annual population growth (%, 1980-85)	Hypothetical size of stationary population (000)	Per caput GNP - 1982 (US $)
Mexico and Central America				
Mexico	78 996	2.6	199 000	2 270
Guatemala	7 963	2.9	25 000	1 130
Belize	163	1.7	-	-
Honduras	4 372	3.4	15 000	660
El Salvador	5 552	2.9	17 000	700
Nicaragua	3 272	3.3	12 000	920
Costa Rica	2 600	2.6	5 000	1 430
Panama	2 180	2.2	4 000	2 120
Andean South America				
Venezuela	17 317	3.3	46 000	4 140
Colombia	27 714	2.1	60 000	1 460
Ecuador	9 378	3.1	25 000	1 350
Peru	19 698	2.6	49 000	1 310
Bolivia	6 371	2.7	22 000	570
Atlantic South America				
Brazil	135 564	2.2	298 000	2 240
Guyana	953	2.0	-	670
Suriname	375	0.1	-	-
Paraguay	3 681	3.0	8 000	1 610
Southern Cone South America				
Argentina	30 564	1.6	54 000	2 520
Uruguay	3 012	0.7	4 000	2 650
Chile	12 038	1.7	21 000	2 210
Caribbean				
Cuba	10 038	0.6	15 000	-
Jamaica	2 336	1.4	5 000	1 330
Haiti	6 585	2.5	14 000	300

continued...

Annex Table 1 (continued)

Country	1982 Population (000)	Rate of annual population Growth (%, 1980-85)	Hypothetical size of stationary population (000)	Per Caput GNP - 1982 (US $)
Caribbean (continued)				
Dominican Republic	6 243	2.3	15 000	1 330
Trinidad-Tobago	1 185	0.9	2 000	6 840
Puerto Rico	3 451	1.5	-	-
Bahamas	230	1.3	-	3 830
St. Chris.-Nevis	53	1.4	-	750
Martinique	328	0.0	-	4 680
Guadeloupe	334	0.1	-	4 200
St. Lucia	130	1.2	-	720
Dominica	76	1.2	-	710
St. Vincent	104	1.2	-	620
Grenada	112	1.2	-	760
Barbados	253	0.8	-	2 900
Netherlands Antilles	264	1.3	-	5 150

Sources: FAO, 1986. FAO Production yearbook. Rome.

United Nations, 1984. United Nations World population chart 1984. New York: Department of International Economic and Social Affairs.

World Bank, 1985. World Development Report 1985. New York: Oxford University Press.

Population Reference Bureau Inc. 1984 World Population Data Sheet. April 1984.

Annex Table 2. Health and Life Expectancy

Country	Infant mortality (aged under one) (No. of deaths per 1 000)	Life expectancy at birth			Protein-energy malnutrition among children under five years of age*				
						---% malnourished---			
		Male	Female	Both	Year	Total	Degree I	Degree II	Degree III
Mexico and Central America									
Mexico	53	64	68	-	-	-	-	-	-
Guatemala	66	58	62	-	1975	81.0	47.5	29.5	5.4
Belize	-	-	-	-	1973	59.2	40.9	18.0	1.2
Honduras	83	58	62	-	-	-	-	-	-
El Salvador	72	62	66	-	-	-	-	-	-
Nicaragua	86	56	60	-	1975	-	-	-	-
Costa Rica	18	72	76	-	1975	-	-	-	-
Panama	33	69	73	-	1975	60.7	48.8	10.8	1.1
Andean South America									
Venezuela	39	65	71	-	1974	48.9	35.3	12.2	1.4
Colombia	54	62	66	-	1966	66.6	45.6	19.3	1.7
Ecuador	78	61	65	-	1965-69	39.7	28.9	9.6	1.2
Peru	83	57	60	-	1965-71	44.5	32.8	10.9	0.8
Bolivia	126	49	53	-	1966-69	39.9	29.0	10.2	0.7
Atlantic South America									
Brazil	73	62	66	-	1968	68.3	48.4	17.2	2.7
Guyana	35	-	-	68	1971	60.7	43.0	16.0	1.7
Suriname	31	-	-	69	-	-	-	-	-
Paraguay	45	63	67	-	1973	7.8	4.9	2.2	0.7
Southern Cone South America									
Argentina	44	66	73	-	-	-	-	-	-
Uruguay	34	71	75	-	-	-	-	-	-
Chile	27	68	72	-	1977	14.9	11.9	2.5	0.5
Caribbean									
Cuba	17	73	77	-	-	-	-	-	-
Jamaica	10	71	75	-	1970	49.8	39.0	9.4	1.4

continued...

Annex Table 2 (continued)

Country	Infant mortality (aged under one) (No. of deaths per 1 000)	Life expectancy at birth			Protein-energy malnutrition among children under five years of age*				
					% malnourished				
		Male	Female	Both	Year	Total	Degree I	Degree II	Degree III
Caribbean (continued)									
Haiti	110	53	56	-	1975	81.9	28.9	35.6	17.4
Dominican Republic	65	61	65	-	-	-	-	-	-
Trinidad-Tobago	26	66	70	-	1970	49.3	36.8	11.1	1.4
Puerto Rico	17	-	-	74	-	-	-	-	-
Bahamas	22	-	-	69	1974	15.9	14.6	0.6	0.9
St. Kitts-Nevis	46	-	-	64	1974	38.8	33.3	5.4	0.1
Martinique	20	-	-	71	-	-	-	-	-
Guadeloupe	23	-	-	70	-	-	-	-	-
St. Lucia	23	-	-	70	1974	43.9	33.0	9.0	1.9
Dominica	13	-	-	65	1976	50.7	38.6	10.3	1.8
St. Vincent-Grenadines	60	-	-	65	1975	30.5	22.7	6.2	1.6
Grenada	15	-	-	70	1975	39.7	29.1	9.0	1.6
Barbados	23	-	-	72	1975	39.5	36.1	3.1	0.3
Netherlands Antilles	25	-	-	-	-	-	-	-	-

* according to the Gomez Classification (I = Slight, II = Moderate, III = Severe).

Sources: World Bank, 1984. World Development Report 1984. New York: Oxford University Press. Table 1, pp. 218-19; Table 23, pp. 262-63.

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World Bank, 1983. World Tables (3rd ed). Vol. II: Social data from the data files of The World Bank. Baltimore: Johns Hopkins University Press.

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UNICEF, 1979. Situacion de la infancia en America Latina y el Caribe, No. 49 (319). Santiago.

Organizacion Panamericana de la Salud, 1976. Situacion nutricional y alimentaria en los paises de America Latina y el Caribe, Pub. 328. Washington DC.

Annex Table 3. Urban populations in Latin America, Africa and Asia

Population	1950		1980		2000	
	Number (million)	%	Number (million)	%	Number (million)	%
Urban areas						
Latin America	66.3	40.6	240.6	64.8	466.2	75.2
Africa	31.8	14.4	133.0	28.9	345.8	42.5
East Asia*	108.9	16.0	359.5	33.1	622.4	45.4
South Asia	107.4	15.5	329.8	23.1	790.7	34.9
Cities of 100 000 or more inhabitants						
Latin America	30.7	18.8	157.8	42.5	354.9	57.3
Africa	14.0	6.4	82.6	18.7	249.1	36.6
East Asia	64.2	9.5	229.8	21.1	431.2	31.5
South Asia	49.0	7.1	204.8	14.4	538.9	23.8
Cities of 1 million or more inhabitants						
Latin America	15.3	9.7	101.3	27.3	232.2	37.5
Africa	3.5	1.6	36.5	7.9	154.6	19.0
East Asia	31.1	4.6	131.9	12.1	261.5	19.1
South Asia	17.9	2.6	105.9	7.4	328.2	14.5
Cities of 5 million or more inhabitants						
Latin America	5.2	3.2	50.6	13.6	147.5	23.8
Africa	0.0	0.0	7.5	1.6	58.3	7.2
East Asia	12.5	1.8	58.1	5.3	125.2	9.1
South Asia	0.0	0.0	45.2	3.2	190.7	8.4

Source: Figures taken or derived from Patterns of urban and rural population growth, United Nations Population Studies No. 68 in Hauser and Gardner (1980).

* East Asia includes Japan.

Annex Table 4. Agricultural data

Country	Total land area (sq km)	Overall population density (per sq km)	Population density (per sq km of agricultural land)
		1980	
Mexico and Central America			
Mexico	1 923 040	35.2	70.9
Guatemala	108 430	66.7	268.6
Belize	22 800	6.3	151.4
Honduras	111 890	32.9	71.6
El Salvador	20 720	215.8	340.1
Nicaragua	118 750	20.6	54.1
Costa Rica	50 660	45.0	111.3
Panama	75 990	23.8	105.8
Andean South America			
Venezuela	882 050	16.4	71.2
Colombia	1 038 700	22.7	72.6
Ecuador	276 840	29.5	161.3
Peru	1 280 000	12.9	54.4
Bolivia	1 084 390	5.1	18.3
Atlantic South America			
Brazil	8 456 510	13.9	53.6
Guyana	196 850	3.7	57.5
Suriname	161 470	2.2	567.7
Paraguay	397 300	7.3	17.0
Southern Cone South America			
Argentina	2 736 690	10.0	15.5
Uruguay	173 620	16.5	18.5
Chile	748 800	14.7	63.8
Caribbean			
Cuba	114 520	86.4*	
Jamaica	10 830	197.6	462.1
Haiti	27 560	180.5	340.7
Dominican Republic	48 380	111.5	198.2
Trinidad-Tobago	5 130	227.7	691.1
Bahamas	10 070	15.1	1 237.6
St. Kitts-Nevis	360	208.3*	
Martinique	1 060	307.5*	
Guadeloupe	1 760	188.6*	
St. Lucia	610	203.2*	
Dominica	750	116.0*	
St. Vincent-Grenadines	340	297.0*	
Grenada	340	338.2*	
Barbados	430	630.2*	
Netherlands Antilles	960	284.3	

* = 1983 data from World Bank.

Sources: FAO, 1984. 1984 Country Tables: Basic Data of the Agricultural Sector. Rome.

World Bank, 1983. World Tables (3rd ed). Vol. II: Social data from the data files of the World Bank. Baltimore: The Johns Hopkins University Press.

Annex Table 5. Land Use in Latin America and the Caribbean - 1983 ('000 ha)

Country	Total land area	Arable land	Permanent crops	Permanent pasture	Forest and woodland	Other land	Irrigated land
Mexico and Central America							
Mexico	192 304	22 050	1 550	74 499	46 910	47 295	5 250
Guatemala	10 843	1 330	485	1 334	4 310	3 384	74
Belize	2 280	46	7	44	1 012	1 171	2
Honduras	11 189	1 570	200	3 400	3 820	2 199	85
El Salvador	2 072	560	165	610	122	615	110
Nicaragua	11 875	1 095	172	5 050	4 150	1 408	82
Costa Rica	5 066	283	352	2 167	1 598	666	28
Panama	7 599	462	122	1 161	4 080	1 774	28
Andean South America							
Venezuela	88 205	3 080	678	17 350	34 120	32 977	320
Colombia	103 870	4 050	1 640	30 000	50 750	17 430	330
Ecuador	27 684	1 552	930	4 600	14 250	6 352	535
Peru	128 000	3 200	317	27 120	70 150	27 213	1 190
Bolivia	108 439	3 250	125	26 950	56 010	22 104	155
Atlantic South America							
Brazil	845 651	63 000	11 700	164 000	567 710	39 241	2 100
Guyana	19 685	480	15	1 230	16 369	1 591	127
Suriname	16 147	46	12	23	15 524	542	39
Paraguay	39 730	1 640	300	15 550	20 450	1 790	62
Southern Cone South America							
Argentina	273 669	26 000	9 700	142 900	59 900	35 169	1 640
Uruguay	17 362	1 400	46	13 632	630	1 654	90
Chile	74 880	5 330	198	11 900	15 480	41 972	1 257
Caribbean							
Cuba	11 086	2 540	675	2 490	1 930	3 451	1 020
Jamaica	1 083	207	62	200	302	312	33
Haiti	2 756	552	347	502	99	1 256	70
Dominican Republic	4 838	1 110	350	2 092	629	657	178
Trinidad-Tobago	513	70	88	11	227	117	21
Puerto Rico	886	70	62	332	187	235	39
Bahamas	1 007	7	2	2	324	672	-
St. Chris.-Nevis	36	8	6	1	6	15	-
Martinique	106	11	8	32	28	27	5
Guadeloupe	176	31	8	22	70	45	2
St. Lucia	61	5	12	3	11	30	1
Dominica	75	7	10	2	31	25	-
St. Vincent	34	13	4	2	14	1	1
Grenada	34	5	9	1	3	16	-
Barbados	43	33	-	33	-	6	-
Netherlands Antilles	96	8	-	-	-	88	-

Source: FAO, 1985c.

Annex Table 6. Average annual deforestation in dense broadleaf forests
('000 ha)

Country	Intact		Productive exploited		Total		Non-productive		All types (total)	
	1976-80	1981-85	1976-80	1981-85	1976-80	1981-85	1976-80	1981-85	1976-80	1981-85
Mexico	190	215	30	30	220	245	200	225	420	470
Costa Rica	15	16	30	32	45	48	15	17	60	65
El Salvador			0.4	0.4	0.4	0.4	3.6	3.6	4	4
Guatemala	16	18	24	27	40	45	24	27	64	72
Honduras	10	9	29	26	39	35	14	13	53	48
Nicaragua	52	60	45	45	97	105			97	105
Panama	10	13	13	14	23	27	8	9	31	36
Central America and Mexico	293	331	171	175	464	506	265	295	729	801
Belize			5	5	5	5	4	4	9	9
Guyana			2	2	2	2	0.5	0.5	2.5	2.5
Jamaica			0.5	0.5	0.5	0.5	1	1.5	2.5	2
Trinidad & Tobago			0.8	0.6	0.8	0.6	0.4	0.2	1.2	0.8
CARICOM			8	8	8	8	6	6	14	14
Cuba			1	1	1	1	1	1	2	2
French Guyana	0.5	0.5	0.5	0.5	1	1			1	1
Haiti			0.8	0.8	0.8	0.8	0.4	0.4	1.2	1.2
Dominican Rep.	1.1	1.2	0.8	1.1	1.9	2.3	0.2	0.2	2.1	2.5
Suriname	0.5	0.5	1.5	1.5	2	2	0.5	0.5	2.5	2.5
Other Caribbean countries	2	2	5	5	7	7	2	2	9	9
Bolivia	15	25	40	50	55	75	10	12	65	87
Brazil			1 030	1 030	1 030	1 030	330	330	1 370	1 360
Colombia	605	605	95	95	700	700	100	120	800	820
Ecuador	160	163	80	82	240	245	60	95	300	340
Paraguay			140	170	140	170	20	20	160	160
Peru	30	40	70	65	100	105	145	155	245	260
Venezuela	30	30	45	45	75	75	50	50	125	125
Tropical Latin America	840	863	1 500	1 537	2 340	2 400	715	782	3 055	3 182
Tropical America	1 135	1 196	1 684	1 725	2 819	2 921	988	1 085	3 807	4 006

Note: Data for temperate South America are not available.

Source: FAO/UNEP, 1981.

Annex Table 7. Area of dense broadleaf forest
('000 ha)

Country	Productive				Unproductive			All types		
	Unmanaged									
	Intact	Exploited	Managed	Total	Physical reasons	Legal reasons	Total	Total	Region (%)	Succession
Mexico	12 280	300		12 580	13 760	210	13 990	26 570	3.6	17 450
Costa Rica	330	770		1 100	218	320	538	1 638	0.2	120
El Salvador		5		5	96		96	101	0.01	22
Guatemala	1 190	1 210		2 400	1 323	62	1 385	3 785	0.5	290
Honduras	297	1 187		1 484	371		371	1 855	0.3	400
Nicaragua	2 600	150		3 750	420		420	4 170	0.6	1 280
Panama	2 125	818		2 943	1 222		1 222	4 165	0.6	124
Central America and Mexico	19 822	4 440		24 262	17 430	592	18 022	42 284	5.8	19 686
Belize		801		801	456		456	1 257	0.2	410
Guyana	12 120	1 345		13 465	4 998	12	5 010	18 475	2.5	200
Jamaica	41	4		45	20	2	22	67	0.01	159
Trinidad & Tobago		134	14	148	60		60	208	0.01	57
CARICOM	12 161	2 284	14	14 459	5 534	14	5 548	20 007	2.7	826
Cuba		795		795	460		460	1 255	0.2	700
French Guyana	7 445	150		7 595	1 305		1 305	8 900	1.2	75
Haiti		14		14	22		22	36	0.01	159
Dominican Rep.	203	194		397	47		47	444	0.06	131
Suriname	12 075	420		12 495	1 755	580	2 335	14 830	2.00	270
Other Caribbean countries	19 723	1 573		21 296	3 589	580	4 169	25 465	3.5	1 186
Bolivia	17 769	12 090		29 850	14 160		14 160	44 010	6.0	1 100
Brazil	288 630	12 000		300 630	51 000	4 650	55 650	356 280	48.5	46 420
Colombia	38 600	900		39 500	4 620	2 280	6 900	46 400	6.3	8 500
Ecuador	10 800	110		10 910	2 970	350	3 320	14 230	1.9	2 350
Paraguay	560	2 480		3 040	940	90	1 030	4 070	0.6	3 270
Peru	37 320	6 000		43 320	25 140	850	25 990	69 310	9.4	5 350
Venezuela	7 600	11 610		19 210	8 160	4 500	12 660	31 870	4.3	10 650
Tropical Latin America	401 270	45 190		446 460	106 990	12 720	119 710	566 170	77.0	77 640
Argentina								59 940	8.2	3 050
Chile								20 250	2.8	
Uruguay								810	0.1	
TOTAL	452 976	53 487	14	506 477	133 543	13 906	147 449	734 926	100	102 388

Source: FAO/UNEP, 1981, for data on Tropical America.

Annex Table 8. Total area of all woody vegetation ('000 ha)

Country	Dense forest	Open forest	Dense and open forest			Fallow forest	Shrub-land	Total woody vegetation		
			Total	% of region	% of country			Total	% of region	% of country
Mexico	46 250	2 100	48 350	4.8	24.51	26 000	59 500	133 850	10.6	67.86
Costa Rica	1 638	160	1 798	0.2	35.32	120	120	2 038	0.2	40.04
El Salvador	141	-	141	0.01	6.72	22	293	456	0.04	21.72
Guatemala	4 442	100	4 542	0.5	41.71	360	1 505	6 407	0.5	58.84
Honduras	3 797	200	3 997	0.4	35.66	680	1 220	5 897	0.5	52.61
Nicaragua	4 496	-	4 496	0.5	32.28	1 370	210	6 076	0.5	43.62
Panama	4 165	-	4 165	0.4	54.03	124	-	4 289	0.3	55.64
Central America and Mexico	64 929	2 560	67 489	6.7	27.30	28 676	62 848	159 013	12.6	64.31
Belize	1 354	92	1 446	0.1	62.95	525	46	2 017	0.2	87.81
Guyana	18 475	25	18 500	1.8	86.06	200	115	18 815	1.5	87.52
Jamaica	67	-	67	0.01	5.87	159	227	453	0.04	39.67
Trinidad & Tobago	208	-	208	0.01	40.55	57	6	271	0.02	13.84
CARICOM	20 104	117	20 221	2.0	79.46	941	394	21 556	1.7	84.70
Cuba	1 455	-	1 455	0.1	12.71	700	305	2 460	0.2	21.48
French Guyana	8 900	70	8 970	0.9	98.57	75	7	9 052	0.7	99.47
Haiti	48	-	48	0.01	1.73	43	53	144	0.01	5.19
Dominican Republic	629	-	629	0.06	13.00	267	54	950	0.08	19.63
Suriname	14 830	690	15 520	1.5	94.74	270	200	15 990	1.3	97.61
Other Caribbean countries	25 862	760	26 622	2.6	59.76	1 355	619	28 596	2.3	64.19
Bolivia	44 010	24 700	68 710	6.8	62.54	1 100	9 000	78 810	6.2	71.74
Brazil	357 480	211 200	568 680	56.5	66.81	46 420	61 200	676 300	53.6	79.45
Colombia	46 400	5 700	52 100	5.2	45.75	8 500	5 500	66 100	5.2	58.04
Ecuador	14 250	550	14 800	1.5	54.68	2 350	1 050	18 200	1.4	67.24
Paraguay	4 070	28 640	32 710	3.2	80.42	3 270	-	35 980	2.9	88.46
Peru	69 680	1 120	70 800	7.0	55.09	5 350	3 150	79 300	6.3	61.70
Venezuela	31 870	3 300	35 170	3.5	38.56	10 650	2 120	47 940	3.8	52.56
Tropical Latin America	567 760	275 210	842 970	83.7	61.87	77 640	82 020	1 002 630	79.5	73.59
Argentina	7 670	32 300	39 970	4.0	14.4	-	-	39 970	3.2	14.4
Chile	6 250	7 450	8 680	0.9	11.5	-	-	8 680	0.7	11.5
Uruguay	580	-	580	0.06	3.3	-	-	580	0.05	3.3
TOTAL	693 155	318 397	1 006 532	100	-	108 612	145 881	1 261 025	100	-

Source: FAO/UNEP, 1981, for data on Tropical America.

Annex Table 9. Total area of coniferous forests
('000 ha)

Country	Productive				Unproductive			All types		Succession
	Unmanaged									
	Intact	Exploited	Managed	Total	Physical reasons	Legal reasons	Total	Total	Region (%)	
Mexico	500	11 200		11 720	7 810	150	7 960	19 680	67.2	8 550
Costa Rica										
El Salvador		20		20	20		20	40	0.1	
Guatemala		612		612	45		45	657	2.2	70
Honduras	518	978	58	1 554	388		388	1 942	6.6	280
Nicaragua		76	250	326				326	1.1	90
Panama										
Central America and Mexico	1 018	12 906	308	14 232	8 263	150	8 413	22 645	77.3	8 990
Belize		90		90	7		7	97	0.3	115
Guyana										
Jamaica										
Trinidad & Tobago										
CARICOM	0	90	0	90	7	0	7	97	0.3	115
Cuba			200	200				200	0.7	
French Guyana										
Haiti	9	2		11	1		1	12	0.04	33
Dominican Rep.	39	137		176	9		9	185	0.6	136
Suriname										
Other Caribbean countries	48	139	200	387	10	0	10	397	1.4	169
Bolivia										
Brazil	280			280	910	10	920	1 200	4.1	
Colombia										
Ecuador	5			5	15		15	20	0.07	
Paraguay										
Peru	180			180	190		190	370	1.3	
Venezuela										
Tropical Latin America	465	0	0	465	1 115	10	1 125	1 590	5.4	0
Argentina								3 320	11.3	
Chile								1 230	4.2	
Uruguay								20	0.07	
TOTAL	1 531	13 135	508	15 174	9 395	160	9 555	29 299	100	9 274

Source: FAO/UNEP, 1981, for data on Tropical America.

Annex Table 10. Total (1980) and projected area of industrial plantations (1985)
('000 ha)

Country	Broadleaf species									
	Slow growth		Rapid growth		All broadleaf species		Coniferous species		All species	
	Total	1981-85	Total	1981-85	Total	1981-85	Total	1981-85	Total	1981-85
Mexico	37	15	23	10	60	25	62	25	122	50
Costa Rica	1.5	1.2	1.5	0.2	3	1.4	1.6	0.5	4.6	1.9
El Salvador	0.95	0.35	0.65	0.15	1.6	0.5	0.55	0.15	2.15	0.65
Guatemala	16.7	12	5.6	4	22.3	16	33.5	24	55.8	40
Honduras										
Nicaragua							6.3	5	6.3	5
Panama	0.4		0.2	0.1	0.6	0.1	5.2	1.7	5.8	1.8
Central America and Mexico	56	28	31	15	87	43	109	56	196	99
Belize	0.7		0.6	0.1	1.3	0.1	1.9		3.2	0.1
Guyana							1.7	0.5	1.7	0.5
Jamaica	4.05		0.45		4.5		11.9	3.5	16.4	3.5
Trinidad & Tobago	11	1			11	1	7.5	1.5	18.5	2.5
CARICOM	16	1	1		17	1	23	6	40	7
Cuba	12.5	2.5	85	15	97.5	17.5	117	40	214.5	57.5
French Guyana			0.5	0.25	0.5	0.25	0.5	0.3	1	0.55
Haiti										
Dominican Rep.										
Suriname							9	0.5	9	0.5
Other Caribbean countries	13	3	85	15	98	18	127	41	225	59
Bolivia	1.1	0.5	5.9	1	7	1.5	0.9	0.5	7.9	2
Brazil	81	15	1 120	445	1 201	460	1 845	613	3 046	1 073
Colombia	3.3	1	48	16	51.3	17	86.2	25.5	137.5	42.5
Ecuador	7	2.5	44.8	15	51.8	17.5	13.8	5	65.6	22.5
Paraguay	0.3	0.2			0.3	0.2	3.2	1.4	3.5	1.6
Peru			44	11	44	11	3	3	47	14
Venezuela	5	2.5	13.5	7.5	18.5	10	192	80	210.5	90
Tropical Latin America	98	22	1 276	495	1 374	517	2 144	729	3 518	1 246
Argentina									720	
Chile									538	
Uruguay										
TOTAL	183	54	1 393	525	1 576	579	2 403	832	5 237	1 411

Source: FAO/UNEP, 1981, for data on Tropical America.

Annex Table 11. Total (1980) and projected area of non-industrial plantations (1985) in selected countries of the region ('000 ha)

Country			Broadleaf species							
	Slow growth		Rapid growth		All broadleaf species		Coniferous species		All species	
	Total	1981-85	Total	1981-85	Total	1981-85	Total	1981-85	Total	1981-85
Mexico	44	17	30	14	74	31	74	30	148	61
Haiti	2	1			2	1			2	1
Dominican Rep.							8.2	2.5	8.2	2.5
Bolivia	12	2	13	3	25	5			25	5
Brazil	547	170	2 505	1 000	3 052	1 170			3 052	1 170
Paraguay			2.1	1	2.1	1			2.1	1
Peru			69	18	69	18			69	18
Venezuela	8	4			8	4			8	4
Argentina									120	19
Chile									122	
Uruguay									159	15
TOTAL	613	194	2 619	1 036	3 232	1 230	82	32	3 714	1 467

Source: FAO/UNEP, 1981, for data on Tropical America..

Annex Table 12. Principal watersheds of the region

Region Watershed	Country	Area ('000 km^2)	Average flow at outlet (m^3/sec)
North America/Central America			
Usumacinta-Grijalva	Guatemala/Mexico	131	3 300
Bravo	Mexico	238	150
Lerma-Santiago	Mexico	127	365
Balsas	Mexico	110	387
Panuco	Mexico	74	600
Yaqui	Mexico	50	110
Papalcapan	Mexico	47	1 300
San Juan	Cota Rica/Nicaragua	39	1 614
Fuerte	Mexico	34	150
Coco	Honduras/Nicaragua	27	951
Patuca	Honduras	26	825
Ulua	Honduras	23	526
Coatzacoalcos	Mexico	20	600
Grande de Motagalpa	Nicaragua	20	763
Lempa	Guatemala/Honduras/ El Salvador	17	380
Motagua	Guatemala/Honduras	16	252
Caribbean			
Artibonito	Haiti/Dominican Rep.	9	240
Cauto	Cuba	9	150
Yaque del Norte	Dominican Rep.	8	140
South America			
Amazon	Brazil/Colombia/ Ecuador/Peru/ Venezuela/Bolivia/ Guyana	6 059	180 000
Plata	Brazil/Colombia/ Argentina/Paraguay/ Uruguay	3 092	22 000
Orinoco	Colombia/Venezuela	982	23 000
Tocantino	Brazil	864	17 000
S. Francisco	Brazil	631	3 900
Parnaiba	Brazil	352	4 800
Magdalena	Colombia	284	6 000
Essequibo	Venezuela/Guyana	155	5 000
Negro	Argentina	222	1 050
Pendare	Brazil	94	1 100
Doce	Brazil	85	1 000
Courantyne	Guyana/Suriname	79	2 300
Meroni	Suriname/Fr. Guyana	69	2 500
Jequitinhonha	Brazil	70	450
Jaguaribe	Brazil	70	600
Paraguacu	Brazil	60	650
Paraiba do Sul	Brazil	56	900
Contas	Brazil	55	510
Parinha	Brazil	44	300
Itapicuru	Brazil	37	350
Atrato	Colombia	36	2 700
Guayas	Ecuador	35	1 500
Boker	Chile	33	1 500
Olapoque	Brazil/Fr. Guiana	31	1 000
Catatumbo	Colombia/Venezuela	31	350

Source: Dourojeanni, 1982.

Annex Table 13. National and international watersheds

Region / Country / Watershed	Watersheds		Area by watershed	Average precipitation
	National	International		
	('000 sq km)			(mm)
NORTH AMERICA				
Mexico	1 536	437		780
Caribbean			716	1 070
Pacific			837	650
Landlocked			370	390
Total	1 536	437	1 973	
CENTRAL AMERICA				
Belize	11	12	23	
Costa Rica	36	15		
Caribbean			24	
Pacific			27	
El Salvador	8	13	21	1 820
Guatemala	30	79		2 030
Caribbean			86	2 000
Pacific			23	2 130
Honduras	86	26		1 710
Caribbean			92	1 780
Pacific			20	1 380
Nicaragua	82	48		2 140
Caribbean			117	2 210
Pacific			13	1 520
Panama	73	4		3 094
Caribbean			24	3 745
Pacific			53	2 819
Total	326	197	523	
CARIBBEAN				
Bahamas	11.4			
Barbados	0.4			
Cuba	114			1 400
Haiti	21	7		1 380
Jamaica	11			1 980
Dominican Rep.	46	3		1 390
Trinidad & Tobago	5			1 260
Total	208.8	10	218.8	
ANDEAN				
Bolivia	63	1 036		1 250
Plata			230	840
Amazon			719	1 380
Landlocked			150	220
Colombia	456	683		2 400
Orinoco			331	2 160
Amazon			330	2 840
Magdalena			234	1 730
Pacific			73	4 970
Caribbean			116	2 690

continued...

Annex Table 13 (continued)

Region / Country / Watershed	Watersheds		Area by watershed	Average precipitation
	National	International		
	('000 sq km)			(mm)
ANDEAN (continued)				
Ecuador	116	168		2 000
Amazon			150	2 310
Pacific			134	1 640
Peru	271	1 014		1 690
Pacific			277	200
Amazon			962	2 180
Landlocked			56	720
Venezuela	166	746		1 960
Orinoco			630	2 110
Atlantic			43	1 360
Amazon			43	1 320
Caribbean			191	1 330
Total	1 072	3 647	4 719	
ATLANTIC				
Brazil	3 222	5 290		1 790
Amazon			3 841	2 510
North Atlantic			1 826	1 090
Sao Francisco			692	1 020
South Atlantic			796	1 580
Plata			1 420	1 200
Guyana	45	170	215	2 560
Paraguay		407		1 020
Parana			53	1 530
Paraguay			354	940
Suriname	65	98	163	2 420
Total	3 332	5 965	9 297	
SOUTHERN TIER				
Argentina	1 809	968		600
Plata			918	810
Atlantic			1 051	320
Pacific			87	918
Landlocked			771	410
Chile	677	80		1 030
North of Copiapo			282	40
Copiapo-Aconcagua			92	230
Aconcagua-Bio-Bio			113	920
South of Bio-Bio			268	2 390
Uruguay	7	180		1 190
Atlantic			65	970
Plata			122	1 020
Total	2 493	1 228	3 721	
SOUTH AMERICA	6 897	10 840	17 727	
LATIN AMERICA/ CARIBBEAN	8 967.8	11 484	20 451.8	

Source: Dourojeanni, 1982.

Annex Table 14. Per caput use of potable water in the region (1970 estimates)

Region	Country	Present consumption				Future consumption			
		Residential		Public	Rural	Residential		Public	Rural
		min.	max.	---average----		min.	max.	---average----	
		(litres/day)							
NORTH AMERICA									
	Mexico	100	350	35	150	100	350	35	150
	Average	100	350	35	150	100	350	35	150
CENTRAL AMERICA									
	Costa Rica	175	275	-	135	200	300	-	200
	El Salvador	17	295	40	30	130	400	40	80
	Guatemala	150	150	-	25	200	200	-	60
	Honduras	20	270	-	93	160	270	-	113
	Nicaragua	130	220	50	113	240	300	50	123
	Panama	190	300	-	60	210	340	-	75
	Average	114	252	45	34	190	302	45	109
CARIBBEAN									
	Barbados	230	1730	46	467	135	570	46	353
	Haiti	150	200	30	-	175	225	30	30
	Jamaica	320	390	58	170	340	570	68	249
	Dominican Rep.	320	375	75	113	130	340	75	113
	Average	255	674	52	250	195	426	55	136
ANDEAN									
	Bolivia	60	150	18	80	150	250	-	115
	Colombia	113	275	-	120	115	300	-	115
	Ecuador	140	200	-	105	-	-	-	-
	Peru	90	400	28	90	150	300	40	350
	Venezuela	200	300	-	225	400	600	-	175
	Average	121	265	23	124	204	363	40	189
ATLANTIC									
	Brazil	80	500	30	48	100	500	40	48
	Guyana	270	360	-	203	450	550	-	455
	Paraguay	160	350	20	150	160	350	20	150
	Average	170	403	25	134	237	467	30	218
SOUTHERN TIER									
	Argentina	300	600	-	150	250	350	-	150
	Chile	180	400	15	100	250	500	-	100
	Uruguay	120	250	-	140	126	262	-	143
	Average	200	417	15	130	209	371	-	133
SOUTH AMERICA		164	362	23	130	217	400	35	180
LATIN AMERICA AND CARIBBEAN		158	379	39	134	199	370	43	157

Source: Dourojeanni, 1982.

Annex Table 15. Irrigation in Latin America and the Caribbean

Region Country	Irrigated area		Increase in irrigated area		Area irrigated
	1967	1977	Area	(%)	(%)
	............(sq km)...........				
NORTH AMERICA					
Mexico	33 000	50 000	17 000	51.5	38.9
Total	33 000	50 000	17 000	51.5	38.9
CENTRAL AMERICA					
Belize		20	20		
Costa Rica	260	260			0.2
El Salvador	200	500	300	150.0	0.4
Guatemala	480	640	160	33.3	0.5
Honduras	660	800	140	21.2	0.6
Nicaragua	250	740	490	196.0	0.6
Panama	180	250	70	38.9	0.2
Total	2 030	3 210	1 180	58.1	2.5
CARIBBEAN					
Cuba	3 800	7 000	3 200	84.2	5.4
Guadeloupe	20	10	-10	-50.0	
Haiti	460	700	240	52.2	0.5
Jamaica	240	320	80	33.3	0.2
Martinique	10	30	20	200.0	
Puerto Rico	390	390			0.3
Dominican Rep.	1 200	1 400	200	16.7	1.1
St. Lucia	10	10			
St. Vincent	10	10			
Trinidad & Tobago	110	200	90	81.8	0.2
Total	6 250	10 070	3 820	61.1	7.8
ANDEAN					
Bolivia	800	1 200	400	50.0	0.9
Colombia	2 400	2 900	500	20.8	2.3
Ecuador	4 630	5 100	470	10.2	4.0
Peru	10 700	11 800	1 100	30.3	9.2
Venezuela	2 650	3 500	850	32.1	2.7
Total	21 180	24 500	3 320	15.7	19.1
ATLANTIC					
Brazil	6 800	10 000	3 200	47.1	7.8
Guyana	1 090	1 220	130	11.9	1.0
Paraguay	400	550	150	37.5	0.4
Suriname	200	300	100	50.0	0.2
Total	8 490	12 070	3 580	42.2	9.4
SOUTHERN TIER					
Argentina	11 800	15 100	3 300	28.0	11.7
Chile	11 200	13 000	1 800	16.1	10.1
Uruguay	420	600	180	42.9	0.5
Total	23 420	28 700	5 280	22.5	22.3
SOUTH AMERICA	53 090	65 270	12 180	22.9	50.8
GRAND TOTAL	94 370	128 550	34 180	36.2	100

Source: Dourojeanni, 1982 (based on 1978 FAO data).

Annex Table 16. Nominal and potential catch in inland waters of Latin America

Country	Nominal catch(1) 1982	 1983	 1984	Potential catch(2)
	(tonnes per year)			
Argentina	15 395	14 594	9 287	86 000
Bolivia	5 617(a)	5 617(a)	5 617(a)	60 000
Brazil	207 919	205 345	201 000	700 000
Chile	257	253	386	100
Colombia	49 000	45 343	53 354	112 000
Costa Rica	455	523	213	4 000
Cuba	13 629	14 121	16 199	?
Dominican Rep.	1 721(a)	1 721(a)	1 721(a)	2 088
Ecuador	0	0	0	1 000
El Salvador	551	795	1 705	3 000
Guatemala	721	40	54	1 600
Guyana	681	800	800	?
Haiti	300(a)	300(a)	300(a)	?
Honduras	74	65	113	15 000(b)
Jamaica	129	225	450	?
Martinique	0	0	0	?
Mexico	12 743	100 527	116 922	341 000(b)
Nicaragua	486	378	118	60 000
Paraguay	3 400	3 500	5 000	100 000
Peru	17 358	24 610	24 543	340 000
Suriname	82	217	145	3 000
Uruguay	186	57	435	14 000(b)
Venezuela	14 998	20 009	21 073	190 000(b)
TOTAL	345 702	439 040	459 435	2 032 788

(a) Extrapolation.
(b) including coastal lagoons.

Sources: (1) FAO, 1984f; (2) FAO, 1984c.

Annex Table 17. Permanent pastures and grazing lands in the region (1983) (in '000 ha)

Country	Permanent pasture/ grazing land		Forests/ woodlands	Total	% of country
	1983	% change from 1974-76			
Belize	44	+ 19	1 012	1 056	46
Costa Rica	2 167	+ 33	1 598	3 765	74
El Salvador	610	0	122	732	35
Guatemala	1 334	+ 15	4 310	5 644	52
Honduras	3 400	0	3 820	7 220	64
Mexico	74 499	0	46 910	121 409	62
Nicaragua	5 050	+ 10	4 150	9 200	71
Panama	1 161	0	4 080	5 241	68
Central America	88 661		66 002	154 663	9
Cuba	2 490	- 6	1 930	4 420	40
Dominican Rep.	2	0	31	33	44
Haiti	502	- 10	99	601	22
Jamaica	200	- 8	302	502	46
Trinidad/Tobago	11	0	227	238	46
Caribbean	3 205		2 589	5 794	1
Bolivia	26 950	0	56 010	82 960	76
Brazil	164 000	+ 5	567 710	731 710	86
Colombia	30 000	0	50 750	80 750	71
Ecuador	4 600	+ 65	14 250	18 850	65
Fr. Guyana	6	+ 20	7 300	7 306	80
Guyana	1 230	+ 21	16 369	17 590	82
Paraguay	15 550	+ 3	20 450	36 000	89
Peru	27 120	0	70 150	97 270	76
Suriname	23	+ 47	15 524	15 547	95
Venezuela	17 350	+ 3	34 120	51 470	56
Tropical South America	286 829		852 633	1 139 462	74
Argentina	142 900	0	59 900	202 800	73
Chile	11 900	+ 2	15 480	27 380	36
Uruguay	13 632	0	630	14 262	81
Temperate South America	168 432		76 010	244 442	16
TOTAL	546 731		997 234	1 543 965	100

Source: FAO, 1985. FAO 1984 Production yearbook. Rome.

Annex Table 18. Number of livestock in the region (1984)

Country	Number of animals ('000 head)				Total	
	Cattle	Pigs	Sheep	Goats	1984	% change from 1974
Belize	51	20	3	1	75	+ 9
Costa Rica	2 550	223	3	2	2 778	+ 38
El Salvador	937	379	4	14	1 334	- 12
Guatemala	2 605	810	660	76	4 151	+ 53
Honduras	2 434	400	5	24	2 863	+ 21
Mexico	37 500	18 370	6 400	10 000	72 270	+ 26
Nicaragua	2 000	540	3	6	2 549	- 21
Panama	1 470	200	0	7	1 677	+ 10
Central America	49 547	20 942	7 078	10 130	87 697	+ 24
Cuba	6 400	2 300	375	103	9 178	+ 25
Dominican Rep.	1 994	832	78	465	3 369	+ 13
Haiti	1 350	400	92	1 100	2 942	- 20
Jamaica	318	275	6	420	1 019	+ 23
Trinidad/Tobago	76	62	12	49	199	+ 13
Caribbean	10 138	3 869	563	2 137	16 707	+ 11
Bolivia	4 300	1 700	9 200	3 200	18 400	+ 23
Brazil	132 801	33 000	17 500	8 500	191 801	+ 24
Colombia	23 860	2 386	2 660	670	29 576	+ 7
Ecuador	3 300	4 278	2 311	280	10 169	+ 38
Fr. Guyana	14	10	0	0	24	+243
Guyana	312	142	117	75	646	+ 16
Paraguay	5 100	1 350	445	145	7 040	+ 7
Peru	2 825	1 775	14 500	1 900	21 000	- 11
Suriname	53	18	4	10	85	+ 55
Venezuela	12 283	2 584	379	1 335	16 581	+ 34
Tropical South America	184 848	47 243	47 116	16 115	295 322	+ 19
Argentina	53 500	3 800	30 000	3 098	90 398	- 9
Chile	3 870	1 150	6 310	600	11 930	+ 7
Uruguay	9 491	450	23 337	12	33 290	+ 25
Temperate South America	66 861	5 400	59 647	3 710	135 618	- 1
TOTAL	311 394	77 454	114 404	32 092	535 344	+ 14

Source: FAO, 1985. FAO 1984 Production yearbook. Rome.

Annex Table 19. Number of livestock per caput and total production of meat and milk in the region (1984)

Country	No. of livestock (per caput)	Total production Meat	 Milk
		----('000 MT)---	
Belize	0.48	2	4
Costa Rica	1.10	71	340
El Salvador	0.25	43	249
Guatemala	0.51	78	330
Honduras	0.68	85	280
Mexico	0.94	1 351	7 227
Nicaragua	0.81	74	125
Panama	0.79	59	92
Central America	0.85	1 763	8 647
Cuba	0.92	235	1 100
Dominican Republic	0.55	63	460
Haiti	0.46	46	22
Jamaica	0.45	22	48
Trinidad and Tobago	0.18	4	8
Caribbean	0.65	370	1 638
Bolivia	2.97	158	80
Brazil	1.45	3 223	10 500
Colombia	1.05	785	2 800
Ecuador	1.12	181	990
Fr. Guyana	0.33	2	1
Guyana	0.69	6	0
Paraguay	1.97	154	15
Peru	1.09	203	165
Suriname	0.24	2	780
Venezuela	0.93	396	1 487
Tropical South America	1.35	5 110	16 818
Argentina	3.00	2 919	5 200
Chile	1.00	276	950
Uruguay	11.13	429	880
Temperate South America	3.02	3 624	7 030
TOTAL	1.37	10 867	34 133

Source. FAO, 1985. FAO 1984 production yearbook. Rome.

Annex Table 20. Process for executing a regional development planning study

Phase I	Phase II
Development diagnosis	Project formulation and preparation of action plan
Activities:	
Diagnosis of region: - Sectoral analysis - Spatial analysis - Institutional analysis - Environmental analysis - Synthesis: needs, problems, potentials, constraints Relation to national plans, strategies and priorities Development strategies: - Formulation and analysis of alternatives - Identification of project ideas	Project formulation (profile or feasibility) and evaluation: - Production sectors (agriculture, forestry, fisheries, livestock, agro-industry, industry, mining) - Support services (marketing, credit, extension) - Social development (housing, education, labour training, health) - Infrastructure (energy, transportation, communications) - Urban services - Natural resources management Action plan preparation: - Formulation of packages of projects - Policies for priority areas and sectors - Enabling and incentive actions - Investment timetable - Evaluation of funding sources - Institutional development and training - Promotion
Products:	
Interim report (Phase I report): - Diagnosis off region - Preliminary development strategy - Identified projects	Final report: - Development strategy - Action plan - Formulated projects - Supporting action
Time frame:	
9 to 12 months (12 to 18 months historically)	12 to 18 months

Source: OAS, 1984.

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